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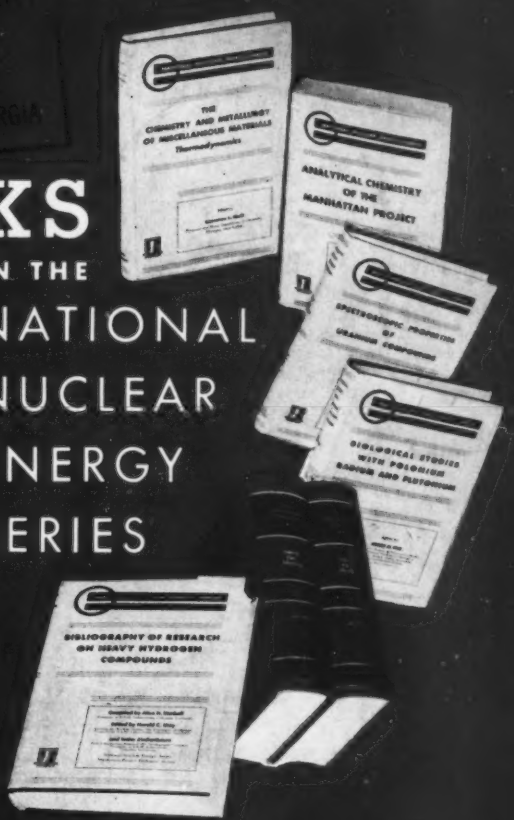

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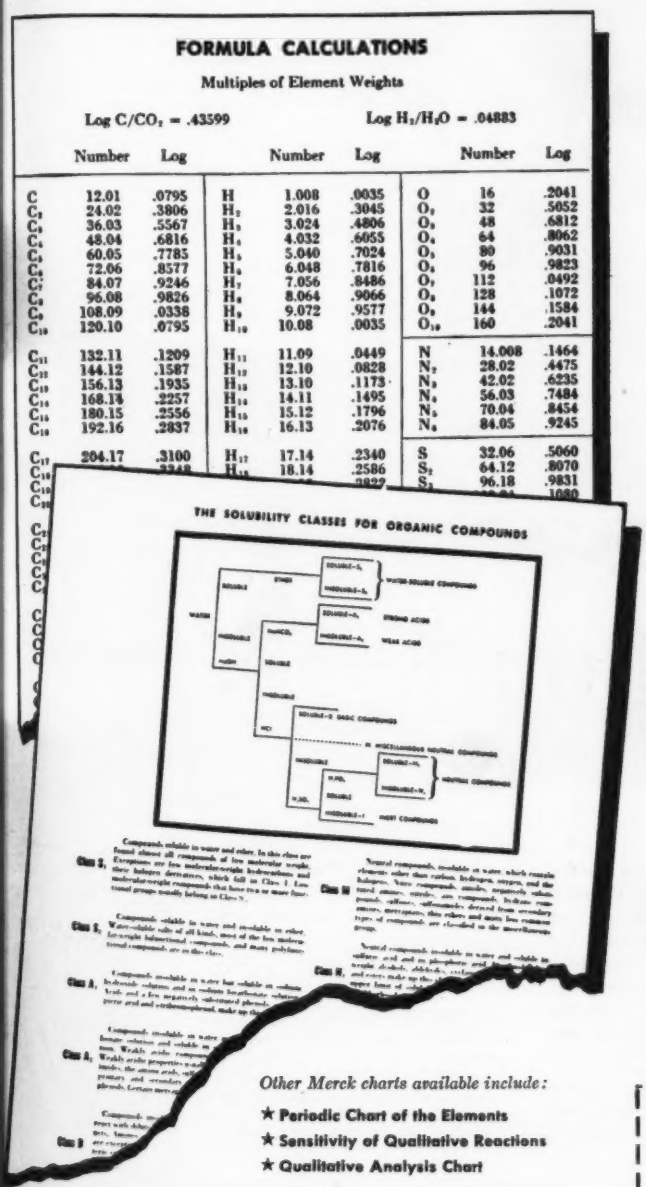

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Log C/CO_2 = .43599 Log H_2/H_2O = .04883

	Number	Log		Number	Log		Number	Log
C	12.01	.0795	H	1.008	.0035	O	16	.2041
C_2	24.02	.3806	H_2	2.016	.3045	O_2	32	.5052
C_3	36.03	.5567	H_3	3.024	.4806	O_3	48	.6812
C_4	48.04	.6816	H_4	4.032	.6055	O_4	64	.8062
C_5	60.05	.7785	H_5	5.040	.7024	O_5	80	.9031
C_6	72.06	.8577	H_6	6.048	.7816	O_6	96	.9823
C_7	84.07	.9246	H_7	7.056	.8486	O_7	112	.0492
C_8	96.08	.9826	H_8	8.064	.9066	O_8	128	.1072
C_9	108.09	.0338	H_9	9.072	.9577	O_9	144	.1584
C_{10}	120.10	.0795	H_{10}	10.08	.0035	O_{10}	160	.2041
C_{11}	132.11	.1209	H_{11}	11.09	.0449	N	14.008	.1464
C_{12}	144.12	.1587	H_{12}	12.10	.0828	N_2	28.02	.4475
C_{13}	156.13	.1935	H_{13}	13.10	.1173	N_3	42.02	.6235
C_{14}	168.14	.2257	H_{14}	14.11	.1495	N_4	56.03	.7484
C_{15}	180.15	.2556	H_{15}	15.12	.1796	N_5	70.04	.8454
C_{16}	192.16	.2837	H_{16}	16.13	.2076	N_6	84.05	.9245
C_{17}	204.17	.3100	H_{17}	17.14	.2340	S	32.06	.5060
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C_{19}						S_3	96.18	.9831
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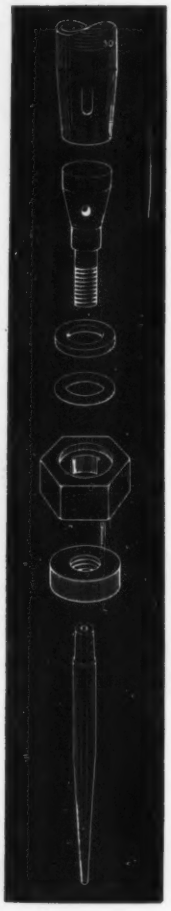

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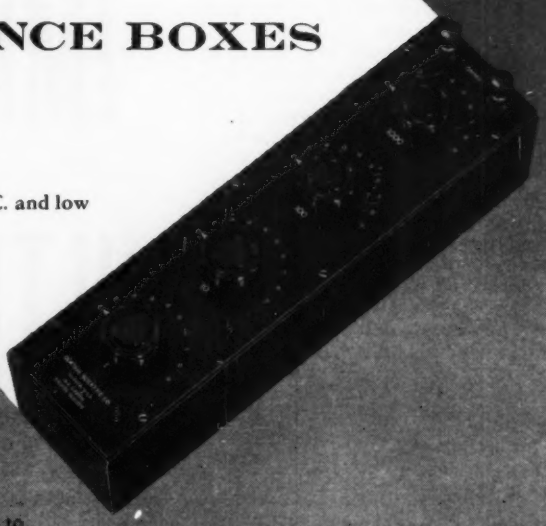

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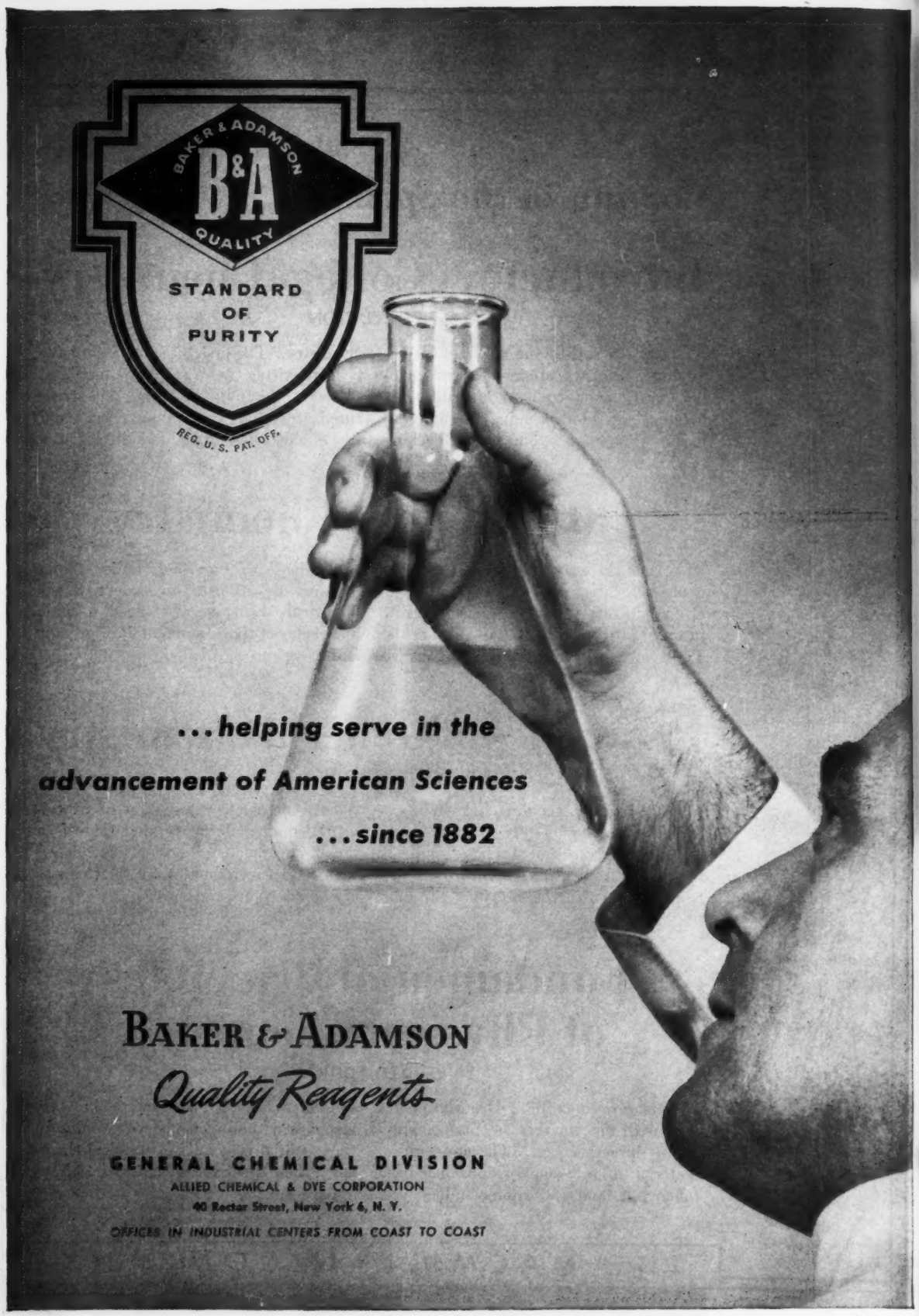
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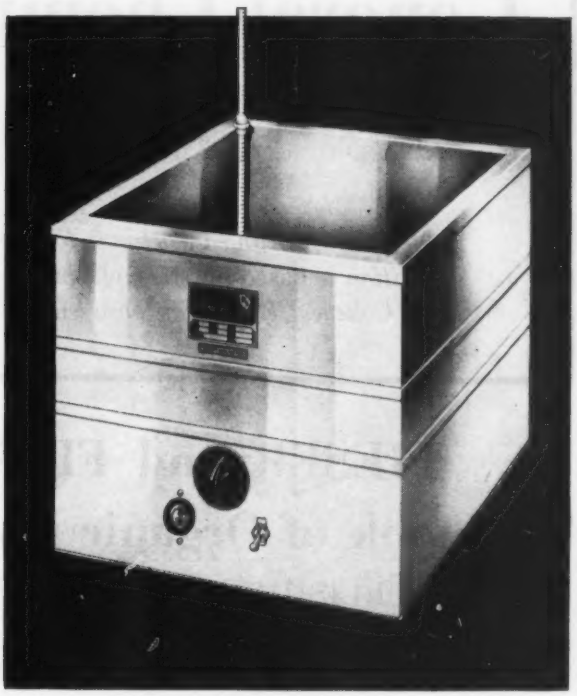

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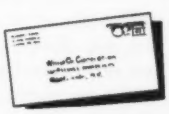
Purchasing for an educational institution is a year-round problem, heightened by the advent of the second term Hundreds of these laboratories have for years met this problem the quick, dependable way by using the facilities of WILL known for years as a specialist in the educational field. Whether your need is for Equipment for any of the thousands of items of Glassware for everyday laboratory Supplies or for tested, pure Chemicals rely on WILL for guaranteed satisfaction. Five conveniently located office-warehouses carrying extensive stocks of the varied items used in educational laboratories, and all linked by teletypewriter inter-communication, afford speedy delivery of orders. Send your list  to the nearest address listed below.

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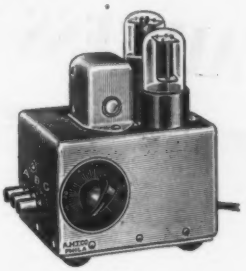
Division of Owens-Illinois Glass Company

ELECTRONIC
AUDIO OSCILLATOR

A noiseless, variable a.c. voltage, constant frequency source for sharp audio balance of bridge circuits in conductivity measurements



3949.

AUDIO OSCILLATOR, Electronic, 1000-Cycle. A noiseless, variable a.c. voltage, constant frequency source for sharp audio balance of bridge circuits, such as the Wheatstone bridge used in conductivity apparatus. The 1000-cycle output is a sine wave with less than 5% harmonic distortion, and has variable amplitude up to 5 volts; output impedance 500 ohms. These characteristics are superior to those of the microphone hummer type oscillator, and the need for sound insulation or a battery is eliminated.

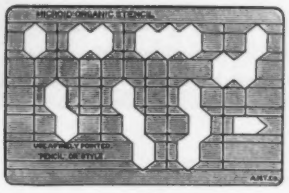
Complete with potentiometer, with graduated reference dial in 100 divisions, for varying the output from 0 to 5 volts; three output terminals A, B and C, and including 12J5GT and 50Y6GT electronic tubes as the oscillator and rectifier, respectively. In use, terminals A and B, or B and C provide variable voltage; full output without variation is obtained by using terminals A and C. By grounding terminal B and using A and C as output terminals, a Wagner ground is obtained. See Frederick Emmons Terman, *Measurements in Radio Engineering, 1st ed. (1935), p. 41.* Mounted on rubber feet; overall dimensions 5 inches long × 4¾ inches wide × 5½ inches high.

3949. Audio Oscillator, Electronic, 1000-Cycle, as above described, complete with 1 ampere fuse and 5 ft. connecting cord and plug; for use on 115 volts, a.c. or d.c. **29.70**
Net weight ..... 2 lbs., 6 oz. Code Word ..... *Ecblu*

10% discount in lots of 6 or more.

ORGANIC FORMULAE STENCIL

For facilitating the drawing of complex organic structural formulae



9221.

STENCIL, DRAWING, ORGANIC FORMULAE, Microid, consisting of a flexible, transparent plastic plate with cutouts of eight characteristic ring systems, which facilitates the drawing of complex organic structural formulae of almost any five or six-membered ring compounds. Can be used with pen or pencil, and is provided with both horizontal and vertical guide lines for easy alignment. The ortho, meta and para positions correspond with the line spacing on a standard typewriter, and the ring systems are separated by the exact width of the benzene ring. Overall dimensions 5 inches long × 3 inches wide; benzene ring ⅝ inch high × 13/32 inch wide.

9221. Stencil, Drawing, Organic Formulae, Microid, as above described **2.04**
Net weight ..... ½ oz. Code Word ..... *Oihdi*

10% discount in lots of 12 or more.

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A Truly Superior Balance in STAINLESS STEEL

The OHAUS HARVARD TRIP BALANCE with STAINLESS STEEL PLATES and BEAMS

Model 550-S Popular, Double Beam Balance

Specifications and Prices

MODEL NO.	Single Beam Balance 450-S	Double Beam Balance 550-S
BEAM CALIBRATIONS	10 x 0.1 g.	200 x 10 g. lower beam 10 x 0.1 g. upper beam
SENSITIVITY	0.1 g.	0.1 g.
CAPACITY	2 Kg. rated 5 Kg. actual	2 Kg. rated 5 Kg. actual
PRICES	$17.40	$20.70

Also available with avoirdupois, apothecary and troy beam calibrations.

The desirable Harvard Trip Balance is a co pletely modernized scale equipped with two stainless s weighing platforms—heat, corrosion and chemical resist —and stainless steel relief etched beams.

Ohaus patented bearing construction, employing self-ali ing, polished agate bearings against precision hollow grou tool steel knife edges, insures the maximum sensiti attainable with this type of balance.

The ruggedly-built Harvard Trip Scale features prop hardened bearing parts with all vital components hea plated. The scale is capable of withstanding heavy o loading without danger of deflection.

Since 1907, Ohaus has furthered their reputation as s specialists. The Ohaus trade mark on any balance is y assurance of superior craftsmanship and exempl performance.

The Harvard Trip Balance is also available with glass pla removable brass pans, scoops or iron plates.

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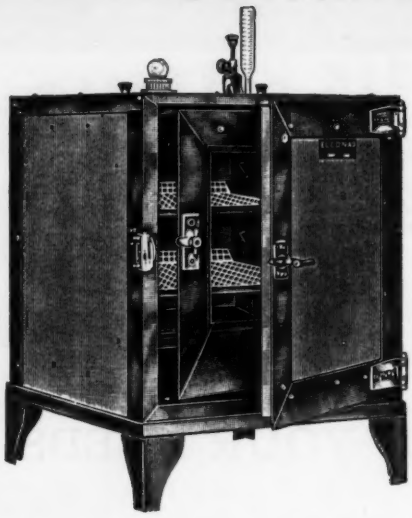


ELCONAP-INCUBATORS

AUTOMATIC • ELECTRIC • ANHYDRIC

ELCONAP type "A" incubators are constructed of asbestos transite with insulated walls and are trimmed in stainless steel. The asbestos surfaces are painted with a special fume and heat resistant grey enamel. All Elconap incubators are furnished with inner glass doors. The large size type A4 and A5 incubators are provided with two thermostats to assure precision of control throughout the chamber. Elconap type "A" incubators have a working temperature range from room to 70° C and an operating sensitivity of ±0.5° C. Incubators are supplied complete with thermometers, pilot *light* thermoregulator, cord and plug. Please specify type of current when ordering.

Guarantee: *All Elconap products carry a five year guarantee against mechanical defects.*

Type	A1	A2	A3	A4	A5
Height	13	19	28	28	32
Width	12	16	18	36	36
Depth	12	14	20	20	20
Shelves	2	2	3	3	3
Each	**$110.00**	**$161.70**	**$200.20**	**$327.80**	**$395.00**
Each with floor stand	....	....	**$224.40**	**$360.80**	**$430.20**

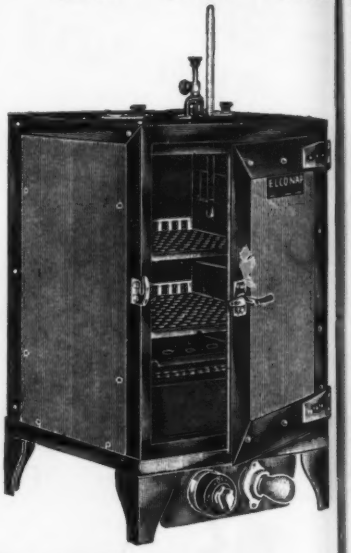
ELCONAP-OVENS

THERMOSTATICALLY CONTROLLED

ELCONAP Type "AO" ovens are of durable construction combined with pleasing appearance and precise performance.

The cabinets are constructed of asbestos transite with suitable insulation and are trimmed in stainless steel. All asbestos surfaces are painted in a special grey heat and fume resisting enamel except on Models AO-3S, AO-S and AO-4S which are in their natural finish. Ovens are equipped with a simple and reliable thermostat, pilot light, and switch. Elconap ovens are guaranteed for five years against mechanical defects.

TYPE	AO-1	AO-2	AO-3	AO-3S	AO-S	AO-4	AO-4S
Height	12	14	12	12	12	14	14
Width	10	18	10	10	14	18	18
Deep	10½	12	10½	10½	12	12	12
Watts	800	1500	800	800	1000	1500	1500
Temp. Range °C	145	145	165	180	180	165	180
Price	**$88.00**	**$138.00**	**$115.00**	**$115.00**	**$130.00**	**$180.00**	**$180.00**



ELCONAP-WATER BATHS

AUTOMATIC TEMPERATURE CONTROL

ELCONAP constant temperature water baths are guaranteed for constant precise performance. Operating sensitivity is within 0.5° C. Temperature range is from room to 65° C or higher depending on the type of bath. Elconap baths are constructed of monel metal eliminating rust or corrosion with proper insulation between walls. A special deflecting septum radiates the heat and accelerates circulation of the water resulting in more even heat distribution, accuracy of control, and uniformity. An inner shelf permits placement of all types of racks, flasks and beakers. The Elconap Baths are guaranteed for five years against mechanical defects.

Please specify type of current when ordering.

Model No.	400	405	405/3	410	410/3	420
Inside Width	5"	13½"	13½"	12"	12"	30"
Inside Length	11¾"	11¾"	11¾"	24"	24"	24"
Inside Depth	7"	7"	7"	7"	7"	12"
Temp. Range	65°	65°	100°	65°	100°	65°
Without Cover	**$91.30**	**$115.50**	....	**$214.50**	....	**$325.00**
With Cover	**$96.80**	**$132.00**	**$195.00**	**$236.50**	**$290.00**	**$352.50**

Bulletins on other Elconap products sent on request.

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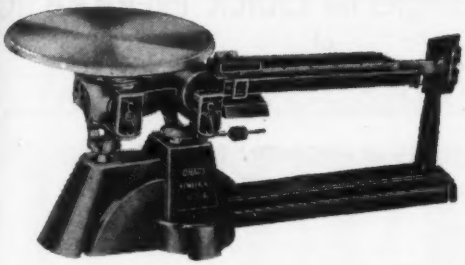
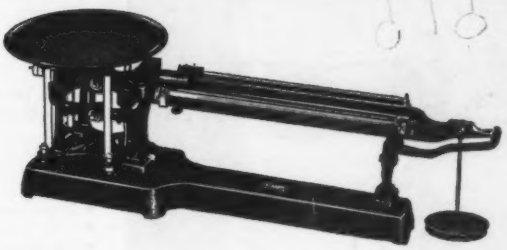
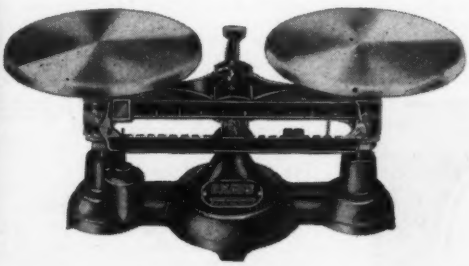


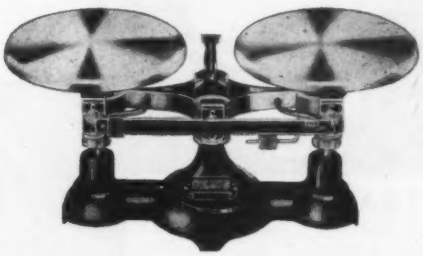
No. 1750s OHAUS TRIPLE BEAM BALANCE with six inch stainless steel plate and beams. Front beam calibrated 10 grams x 1/10 gram; center beam 500 grams x 100 grams; back beam 100 grams x 10 grams. Sensitivity 1/10 gram. Capacity 2610 grams with attachment weights. Without attachment weights **Each $17.40**
Attachment Weight 500 grams **Each .85**
Attachment Weight 1000 grams **Each 1.45**



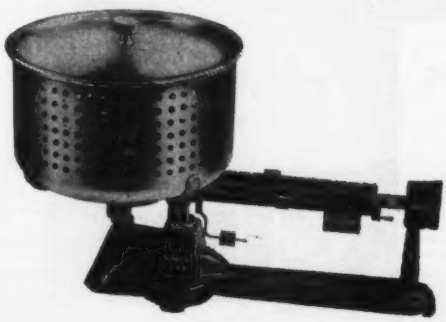
No. 1830 OHAUS SOLUTION BALANCE with a capacity of 20 kg, and a sensitivity of 1 gram. Balance has a 2 kg sliding tare beam and two graduated beams; one 100 grams x 1 gram and 1 kg x 100 grams. An auxiliary set of slotted weights are provided, one each 1, 5, 10 kg and two 2 kgs. **Each $93.00**



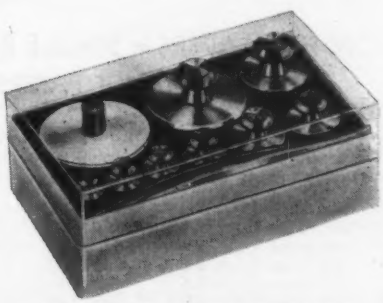
No. 1715s OHAUS DOUBLE BEAM BALANCE with six inch stainless steel plates and beams. Upper beam is calibrated 10 grams x 1/10 gram; lower beam 200 grams x 10 grams. Sensitivity 1/10 gram. Rated capacity 2 kg, 5 kg can be used. The "Ohaus" trade mark assures superior performance. **Each $20.70**



No. 1735s OHAUS SINGLE BEAM BALANCE with six inch stainless steel plates and beam. Beam is calibrated 10 grams x 1/10 gram. Sensitivity 1/10 gram. Rated capacity 2 kg, 5 kg can actually be used. "Ohaus" has been making these rugged scales since 1907. **Each $17.40**



No. 1102 OHAUS ANIMAL BALANCE with a removable perforated aluminum subject box measuring 9" wide x 5" deep with cover. For weighing live animals in biological experiments. Balance has three beams calibrated same as No. 1750s Triple Beam Balance. Capacity with attachment weights 2610 grams. Without attachment weights. **Each $34.80**



No. 2048 OHAUS LABORATORY WEIGHTS in a clearview plastic case. 50 grams to 10 mg; complete with stainless steel forceps. Every weight is adjusted to well within Class "C" tolerances. Gram weights are of lacquered brass, fractional weights are of aluminum. **Per set $2.50**

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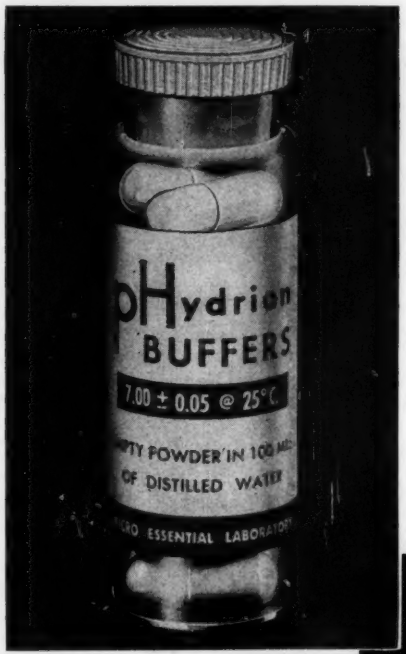

pHYDRION BUFFERS for QUICK PREPARATION of Fresh Solutions of Known pH Values

For the setting of Electrometric pH Instruments and for other Laboratory requirements of a buffered solution.

FEATURES of HYDRION BUFFERS

- Quickly and completely soluble
- Accurate to ±0.05 pH unit
- Dry powder is stable
- Fifty Buffers, pH 2.0 to 12.0 in steps of 0.2 pH units
- Packaged 12 capsules (each making 100 ml.) in a vial. 6 vials in a carton

PRICE

Each vial . . . . . $ 2.00
Carton of 6 vials (one pH unit) 11.00

pHYDRION TEST PAPERS in DOUBLE DISPENSERS

Convenient—Accurate Check for pH Control Tests

The Hydrion double roll dispenser contains two 15 foot rolls of Hydrion Test Paper. Hydrion pH Papers are available in two general classes. The Hydrion Wide Range Papers show sharp color for each full pH unit. The Hydrion Short Range Papers have sharp color changes for each HALF pH unit.

SHORT RANGE PAPERS

Double Roll Dispenser — Sharp Color change for each HALF pH unit.

No. 1–5	pH range	1.0 to 5.5
No. 3–8	pH range	3.0 to 8.0
No. 6–9	pH range	6.0 to 9.5
No. 8–12	pH range	8.0 to 12.0
No. 10–14	pH range	10.0 to 14.0

Dispenser complete with 2 rolls of paper $2.00

WIDE RANGE PAPERS

Sharp color change for each FULL pH unit.

No. 150	Hydrion AB Dispenser	pH 1 to 11
No. 151	Hydrion 4–9	pH 4 to 9
No. 152	Hydracid	pH 1 to 6
No. 153	Hydralk	pH 6 to 11
No. 154	Hydrion C	pH 11 to 12
No. 156	Hydrion D	pH 12 to 13
No. 157	Hydrion E	pH 13 to 14

Dispenser complete with 2 rolls of paper $1.50

pHYDRION TEST PAPERS in SINGLE ROLL DISPENSERS

SHORT RANGE PAPERS

Hydrion Short Range and Control Test Papers are available in the new improved Single Roll Dispenser. The Hydrion Single Roll Dispenser is inexpensive, easy to refill, and can be carried in the vest pocket.

No. 310	pH range 0.0 to 1.5	No. 350	pH range 6.8 to 8.4
No. 315	pH range 1.0 to 2.5	No. 355	pH range 7.2 to 8.8
No. 318	pH range 1.2 to 2.4	No. 358	pH range 8.0 to 9.5
No. 320	pH range 1.4 to 2.8	No. 360	pH range 8.2 to 9.8*
No. 325	pH range 3.0 to 5.5	No. 366	pH range 9.0 to 10.0
No. 330	pH range 3.4 to 4.6	No. 370	pH range 9.2 to 10.6*
No. 333	pH range 4.8 to 6.7	No. 375	pH range 10.0 to 12.0
No. 335	pH range 5.2 to 6.6	No. 380	pH range 10.2 to 12.0
No. 340	pH range 5.6 to 6.8	No. 390	pH range 11.8 to 13.4
No. 345	pH range 6.0 to 8.0	No. 395	pH range 12.5 to 14.0

* Suitable for testing Soap Solutions

PRICE: Single Roll Dispensers containing 15-foot roll of any of the Short Range or Control Papers . . . . . **each, complete $1.00**

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Syringes		Flasks
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Operating Knives	Pipettes	Kitchen Equipment
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REMOVES DIRT, BLOOD, TISSUE FROM GLASS, PORCELAINWARE AND SURGICAL INSTRUMENTS
—makes them sparkling clean, film-free and streakless.

WORKS EQUALLY WELL IN HARD OR SOFT WATER
—dirt, grime, grease, etc., lift right off.

SAVES TIME, SAVES ENERGY
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ECONOMICAL
—a spoonful makes a whole gallon of active cleaner.

RECOGNIZED AND ACCEPTED
—for over ten years in leading hospitals, surgical clinics and scientific laboratories as the scientifically correct cleaner for all types of instruments and equipment.

PROMINENT GLASS MANUFACTURERS
—recommend ALCONOX for ampoule and laboratory glassware washing.

Box of 3 lb.	Price	**$ 1.95**
Carton (12 boxes of 3 lb.)	ea.	**18.00**
Bag of 50 lb.	lb.	**.40**
Barrel of 300 lb.	lb.	**.37**

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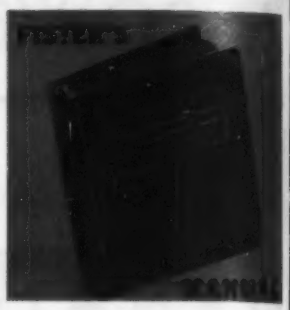

A specially selected list of Baker & Adamson Reagents for use with the methods outlined in the "Manual of Standardized Procedures for Spectrophotometric Chemistry" by Harold J. Fister, as recommended by the author.

		¼ Lb.	1 Lb.
125	ACETIC ACID, A.C.S.		.97
141	ACETIC ANHYDRIDE, A.C.S.	.62	1.43
154	ACETONE, A.C.S.		.65
418	ALUMINUM CHLORIDE, Crystals Reagent	.48	.95
412	ALUMINUM SULFATE, Crystals, Reagent		1.00
415	AMMONIUM CITRATE, Crystals, Reagent	.70	1.65
162	AMMONIUM HYDROXIDE, A.C.S.		.86
410	AMMONIUM OXALATE, Crystals, A.C.S.	.65	1.50
416	AMMONIUM THIOCYANATE, Crystals, A.C.S. Calibration Standard	.76	2.00
183	iso-AMYL ALCOHOL, A.C.S.		1.38
420	ARSENIC ACID, Crystals, Reagent	.96	2.52
424	BARIUM CHLORIDE, Crystals, A.C.S. Calibration Standard	.43	.74
207	BENZOIC ACID, A.C.S.	.69	
425	BORIC ACID, Powders, A.C.S.		.58
155	BROMINE A.C.S.	.91	1.90
432	CADMIUM SULFATE, Crystals, A.C.S.	1.05	2.83
333	CALCIUM CARBONATE, Iceland Spar, (calcite), Crystals for Standardization, Calibration Standard	.76	2.42
439	CALCIUM CHLORIDE ($CaCl_2\ 2H_2O$), Crystals, A.C.S., for lead		1.03
142	CHLOROFORM, A.C.S.		.81
443	CITRIC ACID, Crystals, A.C.S.		1.08
441	CITRIC ACID, Crystals, Special Low-Lead. For lead		1.33
434	COBALTOUS NITRITE, Crystals, A.C.S.	.93	2.53
430	CUPRIC CHLORIDE, Crystals, Reagent	.78	1.83
100	CUPRIC SULFATE, Fine Crystals, A.C.S.		.85
227	FERRIC AMMONIUM SULFATE, Crystals, A.C.S.	.43	.77
458	FERRIC NITRATE, Crystals, A.C.S.	.62	1.39
457	FERROUS SULFATE, Crystals, Reagent	.72	1.70
456	FORMALDEHYDE, Reagent		.57
293	GLYCERINE, A.C.S.		1.07
460	GLYCERINE, U.S.P. For ammonia		.86
152	HYDROCHLORIC ACID, A.C.S.		1.10
341	IODINE, Resublimed, Crystals, A.C.S.	1.51	4.31
372	LACTIC ACID, 85%, Reagent		1.50
468	LEAD ACETATE, Crystals, A.C.S.	.42	.84
469	LEAD NITRITE, Crystals, A.C.S.	.60	1.32
470	LITHIUM CARBONATE, Powder, Reagent	.99	2.61
467	LITHIUM SULFATE, Granular, Reagent	1.10	3.10
474	MAGNESIUM, Metal, Powder, Calibration Standard	1 oz. for .34	
472	MANGANOUS CHLORIDE, Crystals, Reagent	.61	1.33
471	MERCURY, Redistilled, A.C.S.		2.30
391	METAPHOSPHORIC ACID, Glacial, Pellets, Reagent	.99	2.51
400	NITRIC ACID, Fuming, A.C.S.		1.94
479	OXALIC ACID, Crystals, Special for Standardizing, Calibration Standard	.55	1.10
493	PETROLEUM ETHER, B.R. 20–40°, Special		.95
109	PETROLEUM ETHER, B.R. 30–60°, for cholesterol A.C.S.		.61
348	PHENOL, (Acid Carbolic), Loose Crystals Reagent, Calibration Standard	.50	.98
555	PHOSPHORIC ACID, 85% A.C.S.		.87
489	PHOSPHOROUS ACID, Crystals, Reagent	1.51	4.42
487	POTASSIUM BROMIDE, Crystals, A.C.S. Calibration Standard	.50	.96
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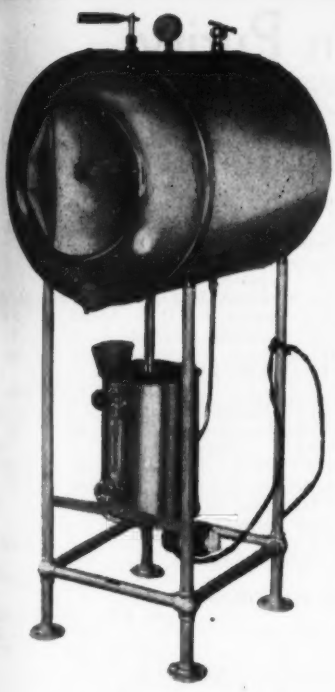

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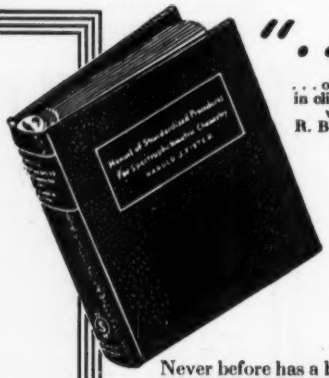

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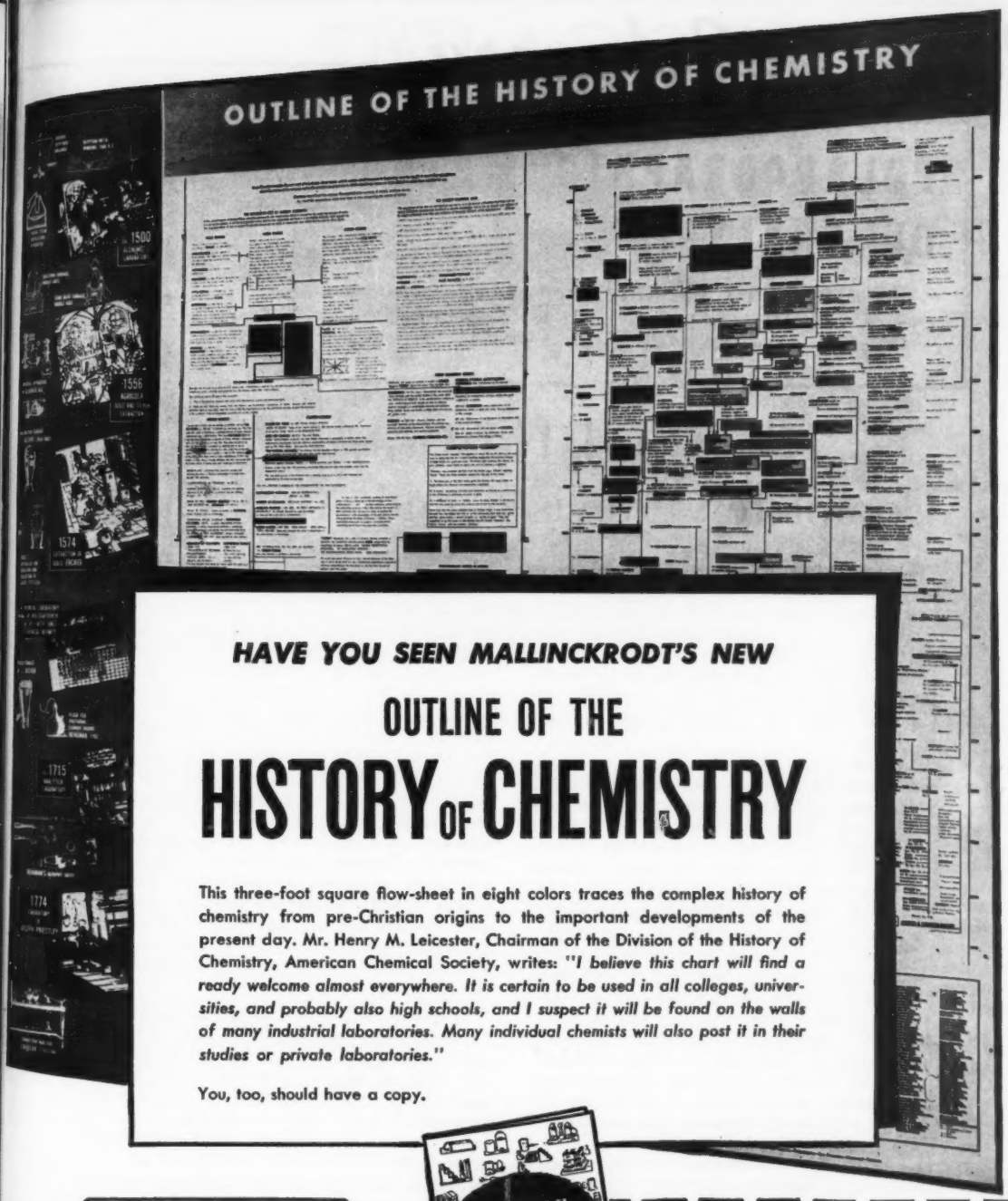

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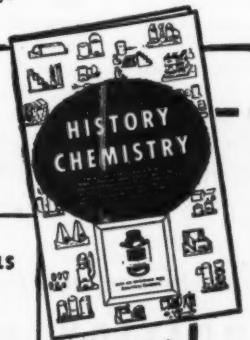

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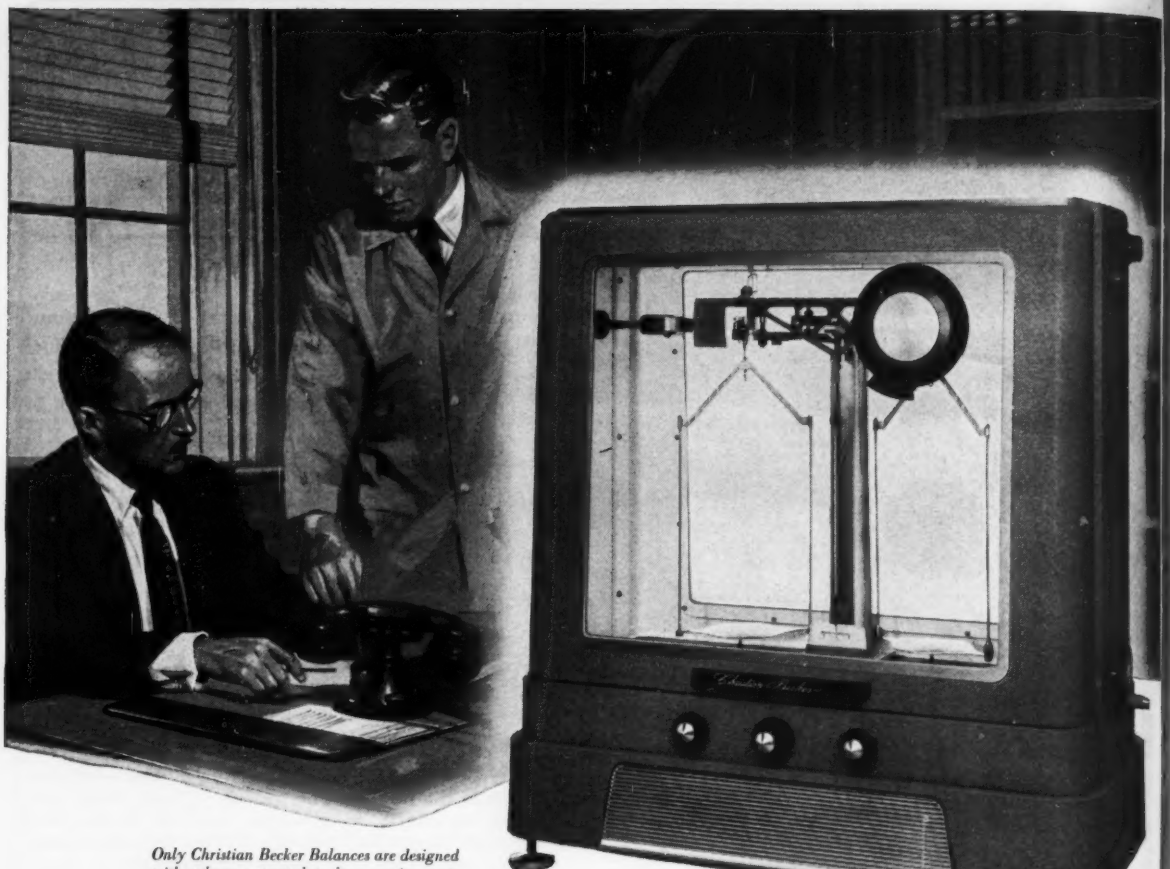

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	7623	temp-current; etc.			x			0 to 0.1 v
Type K-1	7551	general		x				0 to 0.161 v; 0 to 1.61 v
Type K-2	7552	general		x				0 to 0.0161 v; 0 to 0.161 v; 0 to 1.61 v
Students'	7651	general				x		0 to 0.016 v; 0 to 1.6 v
Indicator *	7655	pH, emf's				x		0 to 1.110 v
*	7659	corrosion testing					x	triple; 0 to 4.1 v total
Millivolt *	8667	pyrometer check (lab.); temp.				x		0 to 111 mv
Indicator *	8656 B,D,X	pyrometer check (plant); temp.					x	0 to 16 mv; 0 to 70 mv; or as spec.
*	8657	pyrometer check (plant); temp.					x	0 to 16 mv & 16 to 64 mv; or as spec.
*	8662	pyrom. check (lab. & plant); temp.				x		0 to 16.1 mv; 0 to 80.5 mv
*	8658	pyrom. check (lab. & plant); temp.					x	single; direct-reading temp.
Temperature *	8659	pyrom. check (lab. & plant); temp.					x	double; direct-reading temp.
Indicator *	8663-CD	body temps.					x	25 to 125 F; −3.9 to +51.7 C
*	8663-X	temp. check (lab. or plant)					x	single or double, as spec.
Panel Indicator *	8671-76	temp. meas.					x	single or double, as spec.
pH Indicator *	7663-A1	pH; emf cell potentials					x	0 to 13 pH; 0 to 1.100 v
Brooks (Deflection)	7630	ammeter, voltmeter, wattmeter test.				x		0 to 153 mv (used with volt boxes and shunts)
	7640	lamp efficiency test.				x		0 to 1.53 v (used with volt boxes and shunts)
Micromax *		automatic indicating, recording, controlling: voltage, temp., pH, etc.					x	as spec.
Speedomax *							x	as spec.

*Self-contained

†Under normal operating conditions, except when using lowest part of ranges.

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

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Arthur Stoll

(See page 24)

Welch

STANDARD MERCURIAL BAROMETER

U. S. Weather Bureau Type

No. 1218.

This barometer is of the standard mercury well, or Fortin, type, which is the type used in the United States Weather Bureau, and other laboratories for observations of the highest accuracy. It consists of a 6-mm heavy-walled glass tube, vacuum-filled with mercury, placed open end down in a cistern of mercury. The tube and cistern are supported and protected by a brass tube in which two long slits have been cut near the upper end so as to show the top of the mercury column within the lower and upper limits of the scale (61 to 81.3 cm). Fastened to the shell alongside the slits are metric and English scales with vernier plates, which are operated up and down by a rack and pinion. The metric reads to .05 mm while the inch vernier reads to .002 inch.

The portion of the casing opposite the cistern has a larger diameter than the upper part and has also a glass window at the mercury level, so that a setting of the mercury surface may be made by a thumb screw pushing against the flexible bottom of the cistern, thus raising or lowering the mercury in the cistern until it just touches the ivory point, which is the zero of the scale. This zero point is permanently fixed to the ceiling of the cistern casing and has, of course, been accurately located so as to fit the interval between 0 and the first graduation on the scale mounted on the upper casing, that is, at 61 cm. The ranges of the scales (61 to 81.3 cm and 24 to 32.7 inches) make the barometer available for elevations of approximately 6000 ft. and for points approximately 1500 ft. below sea level.

The scales are made of non-tarnishable 18 percent nickel silver, polished and formed to the shell. The graduations are engine divided.

A double-scale thermometer is mounted in the casing so that the temperature of the barometer column may at all times be known. All metal parts of the barometer are black-nickel finish. A mounting board is available under No. 1220 as described below.

WOOD BACK ONLY, For Holding Barometer No. 1218. Consists of a wood board to which is attached a brass bracket to receive the ring in the top of the barometer, a ring with steadying screws to clamp about the cistern, and milk-glass reflectors, forming an opaque background for reading the instrument. Essential as a permanent mounting for the barometer.
No. 1220. Each, $15.00

Complete as described with vacuum-filled tube - without wood back,
Each
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Editor's Outlook

As THIS is written, the national state of emergency has just been announced. Inevitably, many things have changed within the last few weeks. Some of these changes have modified the educational scene. Slowly the country is coming to realize that we are "in for it," and while the expressions resulting from this conviction are sometimes tinged with panic they are at least realistic.

We are reluctantly admitting that we can no longer keep on with business-as-usual; it is becoming clear that education-as-usual is also a luxury we cannot afford. Yesterday we were worried lest war lead us to intellectual bankruptcy. Yet the metaphor has this aspect: Bankruptcy can be a beneficent process, enabling one to survive his misfortune. The war which looms on the horizon can have even more disastrous consequences.

President Conant's proposal that every 18-year-old young man, without exception, be drafted into military service—a proposal closely echoed by the Association of American Universities—has left most of us gasping. But it may be that something nearly as drastic as this is inevitable. We are in no need of loopholes to escape service; we will, *all* of us, have to find our places in the organization, and in present-day wars there is no spot which is not virtually on the battlefield.

The real principle which we must maintain, however, is the original intention of Selective Service. Our theory of taxation is: from each according to his ability. Service to the country is only a special form of taxation; no one should escape it who is able to "pay," and his payment should be determined by his qualifications to serve.

There are strategic as well as tactical considerations and this national emergency may last a long time. Our 18-year-olds may very well be 40 when this is over, and if we do not do something to conserve and utilize their *best* skills during this period it can be more disastrous than failure to stock-pile strategic minerals.

In no previous war has a really intelligent job been done of making efficient use of the human raw material which presents itself for military service. Selective Service boards, by inclination or orders, have too frequently felt that there was no better place for every young man than the "shooting army." Once in the ranks, recruits have too often been distributed and assigned without regard to their outstanding and valuable abilities. The general impression is that this situation is the inevitable and inherent result of the system of organization; I think it is due to our failure to give intelligent consideration to the problem. Perhaps the first step would be to set up competent civilian control at the proper stage instead of leaving everything to the military, at least distracted, if not prejudiced.

What I am getting at is that some way should be found to save and put to use the really brilliant *brain power* which certainly does exist in this heterogeneous mass of man power we propose to draft early. It *can* be identified and weeded out if we will go to the trouble, and the next war will be won by brain power—if at all.

Dare we admit that this is beyond the ability of our democratic ideals?

*Symposium on the Teaching of Nuclear Chemistry**

COURSES IN RADIOISOTOPES AT THE OAK RIDGE INSTITUTE OF NUCLEAR STUDIES

R. T. OVERMAN
Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tennessee

WAR and postwar research and development in the nuclear sciences created many new and important research techniques applicable to large areas of work. At the same time, security requirements seriously interfered with the normal spread of these techniques to interested laboratories. Thus the need arose for short, concentrated courses aimed at the mature research worker already trained in his given field. The Special Training Division of the Oak Ridge Institute of Nuclear Studies was set up to meet this need.

The most pressing demand for training was in the field of radioisotopes. Here was a research tool of major importance, applicable to very large areas of both fundamental and applied research. By June, 1948, the Atomic Energy Commission was able to meet all legitimate requests for radioisotopes. The mushrooming radiation-instrument manufacturers were turning out counters and other equipment with great speed. Yet there were relatively few research scientists who knew how to apply radioisotopes to their work with safety and efficiency.

Through a series of seventeen courses, the Special Training Division has given the training to more than 550 scientists in this country and a few foreign countries. These radioisotope training courses presented some unusual problems. An important one was the great diversity of background of participants, both in education and experience. They covered fields from agriculture to zoology. Educationally, a major portion of the participants held doctoral degrees in the sciences or in medicine; some held both M.D. and Ph.D. degrees, while a few had only a bachelor's degree, but were group leaders in their institutions.

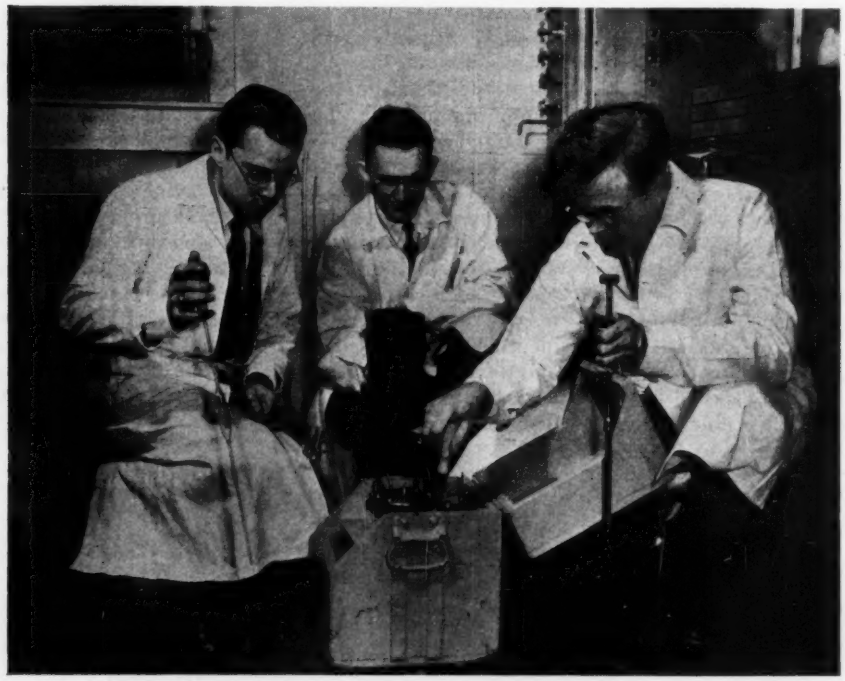
Another problem was the fact that participants varied widely in the ways they planned to use radioisotopes and in the problems they had under study.

To meet these and related problems, the courses were built on the following basic premises:

(1) The work in the course should be predominantly laboratory experience with a minimum of lecture material.

(2) Background material in the development of con-

* Presented at the 116th Meeting of the American Chemical Society, Atlantic City, New Jersey, September, 1949.



Team Removing Sample from Storage Container

cepts should be presented by one lecturer in order to obtain continuity and completeness.

(3) The discussion of techniques and theory of the techniques should be integrated into the laboratory sessions and should be taught primarily by personal supervision of an instructor.

(4) There should be a maximum of two persons to a working group to insure active participation by all in both the laboratory techniques and in measurement experiments.

(5) There should be adequate discussion periods centered around the problems common to the whole class.

(6) There should be a well-equipped library and adequate time available for study to supplement the lecture work of the participants.

(7) There should be ample time for consultation between the participant and his instructors.

(8) The experiments should be as simple as possible so that the radioactivity techniques will be predominant. In general, only a year or so of college chemistry should be necessary as a common denominator for all experiments.

(9) The techniques selected for instructional purposes should be general ones which are required by all participants, regardless of the field in which the radioisotopes are to be used.

By applying these principles, an apparently heterogeneous group of individuals had a group of homogeneous problems to solve and techniques to learn.

Classes were limited to 32 participants, who worked in two laboratories in groups of two for a morning or afternoon session. While laboratory periods were scheduled only for four hours, the experiments frequently took six or more hours by the time the counting work was finished. Laboratory was held on Mondays, Wednesdays, and Fridays, with half the group meeting in the morning and the other half in the afternoon.

The experiments performed were divided into three groups as follows:

(1) The use of measuring instruments and the characterization of radioisotopes.

(2) The purifications and separations that are necessary to make the isotopes ready for use in a given experiment and to bring the radioactive material into a suitable form for activity measurement at the close of the experiment.

(3) Typical applications of radioactive tracers such as studying the distribution of phosphorus in an animal, use of tracers in kinetics, activation experiments, experiments with Carbon 14, preparation of autoradiographs, and the isotope dilution method of analysis.

Each course was set up so that the individual participant would be active in 24 hours of special-topic seminars directed by specialists in various fields, 16 hours of nuclear science background lectures, and 48 hours of laboratory and experimental work. Ample time was allowed for library research work and for consultation with the staff scientists. No examinations, as such, were given in these courses, but each participant had to have an adequate grasp of the field before he satisfactorily completed the course.

The present technical staff is composed of Dr. Ralph T. Overman, chemist and divisional chairman, Dr. Elizabeth Rona, radiochemist, Dr. Rex G. Fluharty, physicist, and Mr. Ralph Firminhac, chemist and instrument designer.

A survey has been made of the fields to which the participants are applying their knowledge and shows how broadly all the fields of science have been covered. The use of radioisotopes in research and in medical treatment is spreading steadily, and among the leaders are those who have attended our basic courses in radioisotope techniques. Although the exact field of application of basic course work is hard to determine for some of our participants, a table of percentages has been worked up which is as nearly correct as possible:

A Radiochemical Laboratory

Medical Research	19.5%
Clinical	13.7%
Biochemistry	7.2%
Biology	14.5%
Agriculture	6.1%
Chemistry	16.4%
Physics	7.9%
Engineering	11.6%
Metallurgy	3.3%

When the first announcement of radioisotope courses was made in April, 1948, a number of scientists from other nations made urgent requests to attend the course.

Many were individuals who were extremely anxious to use radioisotopes in their own research; others were persons who represented their governments in the distribution of radiosiotopes obtained from the United States.

It was not until December, 1948, that the necessary groundwork for admitting foreign scientists could be completed. The Atomic Energy Commission and the State Department had to approve all foreign applications before foreign scientists could be admitted as participants.

Foreign scientists are accepted for training only when their attendance does not deprive qualified United States scientists of the opportunity to take the courses.

An advanced course in instrumentation has been added as the first of an intended series of follow-up courses to the basic techniques sessions. Other advanced courses will be in medical uses of radioisotopes and in autoradiography.

The instrumentation course was attended by 35 participants. No laboratory work was included, but the time was given to special lectures and discussion periods. During the two weeks that the advanced course lasted, each day was devoted to one topic, such as Geiger counters, scintillation counters, etc. Specialists on each subject were presented to give the formal lectures of the morning sessions and to lead the general discussion periods of the afternoon sessions.

Similar plans are being made for the future advanced courses in chemistry, as well as for medicine, biochemistry, autoradiography, and other fields to which radiochemistry is being applied.

NUCLEAR CHEMISTRY AT RENSSELAER POLYTECHNIC INSTITUTE

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A SEQUENCE of two[1] courses in nuclear chemistry is offered at Rensselaer Polytechnic Institute. The first course consists of one term of lectures, fifteen weeks in duration, while the second consists of one term of laboratory work with supporting lectures. The courses are offered by the Department of Chemistry as electives for graduate students in any department. One year of elementary physical chemistry is prerequisite, however. Qualified seniors may elect the courses. Students must complete the one-term lecture course or a course in nuclear physics before electing the laboratory course. The majority of the students take both courses. During one academic year, for example, fourteen students enrolled for the lecture course and eleven for the laboratory course.

NUCLEAR CHEMISTRY LECTURE COURSE

There are three lectures (fifty minutes each) per week. Both the syllabus and time alloted to each topic vary somewhat each time the course is given. Two factors which affect these variations are: (1) the publication of textbooks in nuclear physics and chemistry in which reading and problem assignments can be made, and (2) an increasing tendency for undergraduates to learn more of the background material through outside reading and by electing new courses in other departments.

Homework problems are assigned and a term report is required shortly before the end of the term. The report may be a review of some topic related to the student's major field or it may be a discussion of a recent technical paper dealing with any of the topics covered in the course. A report of the first type might deal with the applications of radioactive tracers to analytical chemistry, for example. In any case, the student is encouraged to read the literature and to become familiar with the work which is being reported currently, where the work is being done, and by whom.

Two or three quizzes and a final examination are given. The final examination is the "open-book" type with the questions designed to encourage the student to apply what he has learned to the solution of problems which are typical of those which might arise in research involving radioactive materials.

[1] Since the presentation of this paper, a third course, Introduction to Nuclear Science and Engineering, has been added to the list of courses offered by the Department of Chemistry. Although related to the courses under consideration, this lecture course is not in sequence with them.

The following is an outline of the topics covered in the lectures.

I. *Historical review of the developments of atomic and nuclear theory*

II. *Nuclear theory*
- A. Properties of nucleons
- B. Nuclear binding energy
- C. Nuclear forces
- D. Energy levels in nuclei
- E. Stability rules
- F. Attainment of stability by means of the various radioactive decay processes

III. *Particle and radiation physics*
- A. Alpha particles
  - 1. Interaction with matter
  - 2. Range-energy determination
  - 3. Alpha particle spectra
  - 4. Decay schemes for alpha emitters
- B. Beta particles
  - 1. Interaction with matter
  - 2. Range-energy determination
  - 3. Beta particle spectra
  - 4. Fermi theory
  - 5. Decay schemes for beta emitters
- C. Gamma rays
  - 1. Interaction with matter
  - 2. Determination of energy
  - 3. Conversion
- D. X-rays
  - 1. Interaction with matter
  - 2. Determination of energy
- E. Positrons
  - 1. Interaction with matter
  - 2. Determination of energy
  - 3. Decay schemes for positron emitters
  - 4. Competition from K-capture
- F. Neutrons
  - 1. Interaction with matter
  - 2. Determination of energy

IV. *Detection of nuclear radiation*
- A. Types of detection equipment
  - 1. Principle of operation
  - 2. Applications
- B. Geiger-Müller tubes
  - 1. Types
  - 2. Characteristics
- C. Scaling circuits
- D. Rate meters
- E. Calibration of counting equipment
- F. Absolute beta-ray counting

V. *Errors in radioactivity measurements*
- A. Review of distribution laws
- B. Radioactive decay as a random process
- C. Calculation of the standard deviation in counting data due to the radioactive process alone
- D. Calculation of total errors in counting data

VI. *Equations for decay and growth of radioactive substances*
- A. Single radionuclide
  - 1. Disintegration constant
  - 2. Half-life
  - 3. Average life
  - 4. Units of radioactivity
- B. Two or more independent radionuclides
- C. Genetically related radionuclides
  - 1. General equations
  - 2. Secular equilibrium
  - 3. Transient equilibrium
- D. Experimental methods for the determination of half-lives

VII. *Artificial radioactivity*
- A. General considerations
  - 1. Conservation of energy and momentum
  - 2. Coulomb barrier
  - 3. Reaction threshold
  - 4. Compound nucleus
  - 5. Cross section and excitation function
- B. Examples of common reactions
- C. Special reactions
  - 1. Oppenheimer-Phillips
  - 2. Fission
  - 3. Spallation
- D. Sources and acceleration of projectiles
- E. Equation for rate of production

VIII. *Heavy radioelements*
- A. Natural series
- B. Artificial series
- C. The transuranics

IX. *Radiation protection*
- A. Hazards associated with various types of radiation
- B. Shielding
- C. Dosage
- D. Instrumentation
- E. Biological effects of radiation

X. *Radiochemical separation processes*
- A. Precipitation methods
  - 1. Isotopic carrying
  - 2. Nonisotopic carrying
- B. Electrodeposition
- C. Ion exchange
- D. Solvent extraction
- E. Adsorption
- F. Volatilization
- G. Szilard-Chalmers process

XI. *Applications of radioactive substances*
- A. Analytical chemistry
- B. Physical chemistry
- C. Organic chemistry
- D. Biochemistry
- E. Metallurgy
- F. Industry and engineering

In certain cases, topics which can be treated more effectively in conjunction with the experiments performed in the laboratory course are not considered in great detail in the lecture course. Perhaps it is in order, therefore, to offer a few general comments concerning the material covered for some of the topics listed above.

For the presentation of nuclear theory the analogy between the concepts of atomic theory and nuclear theory is stressed. At this point the students are introduced to the various charts and compilations of nuclear and atomic data.

A large portion of the term is devoted to particle and radiation physics. This is considered to be one of the most important topics, since experimentation with radioactive materials depends upon the detection of the nuclear radiation emitted and on the interaction of this radiation with matter. The properties of particles such as protons and deuterons are considered under the subject of the production of artificial radioactivity.

Among the types of detection equipment discussed are ionization chambers, proportional counters, scintillation counters, photographic plates, and so forth. The principles of quenching and scaling circuits are

considered. The problems of relative and absolute radiation measurements are compared.

In dealing with the errors of radioactivity measurements it has been found advisable to review the subject of experimental errors in general. Few students have an adequate background in the analysis of experimental data, and, in fact, in some cases the brief formal error treatment given in this course has been the student's first exposure to the subject.

The problem assignments are relatively heavy for that portion of the course dealing with the equations for the decay and growth of radioactive substances.

The students are given an opportunity to practice writing equations for the production of radionuclides. In addition, attention is paid to contaminants which a chemist is likely to find in an irradiated target. Current ideas about the fission process are presented, although rather briefly.

The heavy radioelements are not studied in great detail; rather, their occurrence, production, and general chemistry are summarized.

In considering the problem of radiation protection an attempt is made to impress upon the student the need for careful handling of radioactive substances. At the same time, however, a certain amount of popular misconception and hesitancy toward working with radioactive materials has to be eliminated.

The discussion of separation processes is confined mainly to examples and applications. The principles are reasonably familiar to the chemist from his background in analytical and physical chemistry. A more detailed treatment for some of the processes is given in the laboratory course.

It is felt that little is to be gained by presenting more than a brief general survey of the uses of radionuclides, with a few examples. As pointed out earlier, the students are encouraged to read the journals.

With respect to the time allowed for the various topics, about five weeks are devoted to topics I through III. Similarly, about five weeks are taken for topics IV through VI. The remaining topics are covered, then, in the last third of the term.

NUCLEAR CHEMISTRY LABORATORY COURSE

The laboratory course consists of six hours of laboratory work and one hour of lecture per week. The lecture period is used for a discussion of the experiments with respect to both theory and laboratory technique. Many of the experiments are of the "research" type. The objective of the experiment is defined and one or more procedures are outlined in some detail. The students are encouraged to propose, for discussion and approval, modifications in the details of procedure and technique. To do so, of course, they need to recall and apply the inorganic, analytical, and physical chemistry of their undergraduate training.

Since laboratory time is an important consideration, especially in nuclear chemical experiments, it has been found advantageous to schedule the laboratory periods so that the students can take the six hours during a single day. Such an arrangement can often be made for the graduate students, at least.

The experiments are conducted in a remodeled room in the Institute chemistry building. As part of the remodeling, a hood with good airflow was installed and a heavy rubber covering, turned up on the edges and sealed to the walls and laboratory benches, was placed on the floor. All chemical processing of radioactive materials in this room is carried out in stainless steel trays which are used on the stone bench tops and in the hood.

The counting equipment is in the same room and is kept completely covered when not in use. It is located as far as possible from the processing area. In larger nuclear chemistry quarters which are to be occupied shortly, the counting equipment will be in a separate room near the laboratory.

The equipment in the laboratory includes the following:

Three scalers
Assorted end-window and thin-wall Geiger-Müller tubes with shields, etc.
Aluminum and lead absorbers
One ionization type survey meter
One Geiger-Müller-type survey meter
One Lauritsen electroscope
Pocket ionization chambers and charging unit
Three clinical centrifuges
One analytical balance
One pH meter
One drying oven
Standard chemical glassware
Special micro glassware
Stainless steel trays
Pipetting devices
Tongs of various shapes and sizes
Hot plates and heater lamps
Lead bricks and storage containers
Rubber gloves

With the present facilities, a maximum of six students may be assigned to a given laboratory section. These students then work in pairs. The three pairs may or may not do the same experiment on a given day.

During the term radioactive waste material gradually accumulates. No radioactive waste is allowed to enter the disposal plumbing of the chemistry building. This rule is rigidly enforced. Except for uranium, radium D, and calcium 45, the radioactive substances used in the course are reasonably short-lived; therefore, the waste solutions are stored in glass containers until the activity level reaches background. A burial ground is available for disposal of long-lived waste materials whenever this is necessary.

Certain radiation-protection measures are taken by all personnel working in the radiochemistry laboratory. A portable G-M survey instrument is used to examine glassware, bench tops, etc., for contamination. An ionization-type survey meter is used when shipments of radioactive materials from Oak Ridge are handled and when experiments are performed with a radium-beryllium neutron source. Each student wears two pocket-type ionization chambers at all times. These

chambers are checked at the end of each laboratory period. Complete blood counts are taken at the local hospital once each month.

The experiments performed during the term are as follows:

1. Determination of the operating curve, effective geometry, and resolving time for a G-M tube.
2. Investigation of the errors in radioactivity measurements.
3. Investigation of the factors affecting the backscattering of beta radiation.
4. Use of radiation survey equipment; shielding study.
5. Preparation of a feather analyzer based on RaE.
6. Range and energy determination for the beta radiation from P^{32}, Co^{60}, and Ca^{45}.
7. Determination of the solubility of a relatively insoluble substance.
8. Analysis of an "unknown" by the method of isotope dilution.
9. Determination of the half-life of P^{32}.
10. Separation of UX_1 from uranyl nitrate.
11. Determination of the self-absorption correction for solid samples containing Ca^{45}.
12. Determination of the surface area of calcium sulfate using Ca^{45}.
13. Separation of Ba^{140} and La^{140} by carrier precipitation.
14. Study of the radiation and half-lives of Ba^{140} and La^{140}; transient equilibrium.
15. Preparation and use of an ion-exchange column.
16. Identification of a radioactive "unknown."
17. Use of a quartz-fiber electroscope.
18. Radioactivation with a neutron source.

In planning the experiments, a balance has been made between the cost and the variety of radionuclides. A wide selection of radioactive materials is available from the U. S. Atomic Energy Commission to supplement the naturally occurring materials. Although it is advantageous, perhaps, to supply the students with a variety of radionuclides, the basic objectives can be attained through the use of a few relatively inexpensive radioisotopes.

The completion of each experiment is not determined by a specified predetermined number of laboratory periods. Within reasonable limits, the students are allowed to work on an experiment until it has been completed to the mutual satisfaction of both the students and the instructor. In some cases students are allowed to repeat or extend experiments when they wish to do so. An experiment such as the determination of the half-life of P^{32} is necessarily extended, of course, over most of the term.

In the first few experiments the students become familiar with the equipment with which they are to make radioactivity measurements during the rest of the term. It is intended that the limitations of the counting equipment shall be understood before any careful measurements are attempted. Instruction in the use of the survey equipment for radiation protection is often scheduled for a day when a radioactive sample from Oak Ridge is to be removed from the shipping container or processed. The effectiveness of various types of shielding is studied at the same time.

For Experiment 7 the solubilities of both magnesium ammonium phosphate and silver phosphate have been determined by using P^{32} tracer.

Two types of "unknowns" have been used for the analysis by isotope dilution. Phosphorus 32 has been used for the analysis of a phosphate solution and calcium 45 has been used for the analysis of a solution containing a mixture of calcium and magnesium.

The UX_1-UX_2 equilibrium mixture obtained in Experiment 10 is used to check the effective geometry of a G-M tube previously calculated from measurements made with a RaE source.

In the separation of Ba^{140} and La^{140} from an equilibrium mixture of these two fission products, the uses of isotopic and "hold-back" carriers are illustrated. These two genetically related radionuclides are readily available and are satisfactory with respect to half-life and radiation characteristics for a study of transient equilibrium. The students have an opportunity to compare the experimentally determined growth and decay data with those calculated for the same system as a homework problem in the lecture course.

Since the ion-exchange experiment is rather lengthy and requires the use of considerable glassware, it is usually assigned to a limited number of students. This experiment then becomes a small project for a few students who study the conditions for separating Ba^{140} from La^{140} by ion exchange.

Experiment 16 is somewhat like an examination. A sample of radioactive material which may contain several radionuclides is given to the class. The "unknown" activities are usually different from those used for the previous experiments. In one case, for example, a mixture of relatively long-lived activities which occurred as an impurity in a sample of short-lived material served very effectively as the "unknown." In the interest of completing the experiment in a reasonable number of laboratory periods, the analysis is planned so that each pair or group of students works on one phase of the problem and then contributes its share of experimental data. The findings of the various groups are considered by the class as a whole and a conclusion is reached concerning the identity of each of the component activities in the "unknown."

In the absence of an accelerator, a few short-lived radionuclides can be prepared by irradiation of a sample of an element or a compound in a neutron source. The target isotope of interest must have a large neutron activation cross section. Fifty-four minute In^{116} is an example of a radionuclide which has been used in Experiment 18. Several types of neutron sources are available. It is possible to rent some of these sources on a monthly basis.

In several cases students have been interested in constructing small pieces of equipment for use in the laboratory. Among the items which have been constructed by students are special absorbers and special sample holders.

At the end of the term each student is required to submit a folder containing the data, calculations, and conclusions of all experiments. The last meeting of the term is used for a general discussion and review of all the experiments.

TEACHING NUCLEAR CHEMISTRY AT NOTRE DAME UNIVERSITY

WILLIAM H. HAMILL, RUSSELL R. WILLIAMS, JR., and ROBERT H. SCHULER[1]
University of Notre Dame, Notre Dame, Indiana

BEGINNING with the intensive wartime development of "atomic" energy, the scientific institutions of this country have devoted a considerable fraction of their effort to the study and application of nuclear phenomena. One consequence of this interest has been the appearance of teaching and research programs classified as Nuclear Chemistry or Radiochemistry in the curricula of many universities. These programs most commonly consist of thesis research in the field as well as lecture and laboratory courses offered to advanced students. Less frequently, this field may be represented in the more elementary chemistry courses.

Instruction in nuclear chemistry at Notre Dame takes place at both graduate and undergraduate levels. In the first case it is represented by a lecture course and by thesis research. Undergraduates receive elementary instruction in the lecture and laboratory courses in physical chemistry.

GRADUATE LECTURE INSTRUCTION

The graduate-level lecture course in nuclear chemistry consists of some forty-five lectures given in one semester each year. It is most frequently taken in the first year of graduate study by students majoring or minoring in physical and inorganic chemistry. The course serves as a survey for those who will emphasize some other branch of chemistry and as preliminary training for students who intend to pursue thesis research in the field. A published version of these lectures is available.[2]

In view of the fact that most graduate students in chemistry have had only the most elementary training in physics, it is necessary to spend a considerable portion of the time presenting background information in nuclear physics which is necessary for understanding of the chemical phenomena. A compromise must be adopted between the necessity for adequate treatment of this portion of the material and the desirability of giving proper time and emphasis to the numerous chemical problems. The division of time in our course has been approximately equal between nuclear physics and nuclear chemistry, although no rigid segregation of material has been attempted. For example, the chemical and physical manifestations of nuclear mass are considered before any discussion of nuclear rearrangement reactions. The outline below serves to indicate the portion of the course which might be classified as nuclear physics (Items 1, 3, 4, 5).

COURSE OUTLINE

1. *The atomic nucleus*
   Atomic structure; nuclear mass; nuclear composition; nuclear energetics; unstable nuclei.
2. *Physical and chemical manifestations of nuclear mass*
   Physical properties of isotopic nuclides; chemical properties of isotopic nuclides; concentration of isotopic nuclides.
3. *Devices for preparation and detection of unstable nuclides*
   Detection of nuclear radiations. Efficiency and reliability of detecting devices. Production of unstable nuclides.
4. *Nuclear decay reactions*
   Types of decay; absorption of nuclear radiations. Decay schemes; genetic relationships; rate equations; units and standards.
5. *Nuclear bombardment reactions*
   Nuclear cross section; types of reactions; artificial elements; nuclear fission.
6. *Chemical operations with unstable nuclei*
   Principles; purification and analysis; artificial elements.
7. *Chemical consequences of nuclear reactions*
   Physical basis; neutron capture; isomeric transition; other reactions.
8. *Chemical and biological effects of nuclear radiations*
   Radiations and particles; radiation chemistry; biological effects; health physics.
9. *Applied nuclear chemistry*
   Geochemistry; isotopic exchange; tracer studies; analytical applications.

In the portion of the course which is devoted to the more truly chemical phenomena, an attempt has been made to survey as many as possible of the considerations which arise through the ability to produce, detect, and distinguish between nuclear species. The effect of nuclear mass upon chemical properties, as evidenced by chemical differences between isotopes, receives early consideration. After a discussion of the methods of producing and detecting unstable nuclides, the peculiarities of chemical operations with submicroscopic (tracer) amounts of the species are discussed. A familiarity with this subject is fundamental to many subsequent chemical studies. A description of the chemical properties of those elements known only as artificial unstable nuclides is also included here.

The chemical changes resulting from nuclear reactions are the subject of considerable discussion. On the one hand, the chemical reactions induced in the atom undergoing the nuclear change are discussed. This subject is sometimes called "hot-atom chemistry" and is typified by the Szilard-Chalmers reaction. In contrast, the study of the chemical reactions induced by nuclear radiations as they are absorbed is usually re-

[1] Present address: Canisius College, Buffalo, New York.
[2] WILLIAMS, R. R., JR., "Principles of Nuclear Chemistry," D. Van Nostrand Co., New York, 1950.

ferred to as "radiation chemistry." This subject leads naturally to a discussion of the biological effects of nuclear radiations and of health physics.

The concluding lectures are titled Applied Nuclear Chemistry to indicate that the subject matter is devoted to a survey of the ways in which the techniques of nuclear chemistry can be applied to the solution of problems of other branches of chemistry. A large share of the material may be described by the phrases "isotopic exchange reactions" and "tracer studies" and in these cases the source material is so voluminous that only a few typical examples can be given. The main object is to leave the student with some appreciation of the capabilities of the tracer method, rather than to attempt a critical interpretation of the results.

This lecture course does not attempt to give a complete description of laboratory procedures in either physical or chemical considerations, since elementary training of this nature is available in laboratory courses and advanced training in thesis research.

THESIS RESEARCH

Formal lecture and laboratory training in nuclear chemistry at the graduate level might well be regarded as sterile unless accompanied by an active program of research in this field. At Notre Dame four staff members and approximately fifteen graduate students are conducting research in various phases of nuclear chemistry. The individual problems fall largely into the general fields of radiation chemistry and hot-atom chemistry. Also, several applications of radioactive tracer techniques to the kinetic problems arising in these and allied fields are now in progress.

This research program enjoys generous support from the University and the U. S. Atomic Energy Commission and has its origin in the wartime work of the staff members and several graduate students with the Plutonium Project. It is complemented by active research in nuclear physics at the University and facilitated by contacts with the Argonne National Laboratory in Chicago, in which Notre Dame is a participating university.

UNDERGRADUATE LECTURE INSTRUCTION

The usual two-semester lecture course in elementary physical chemistry has become less and less capable of handling effectively the increasing number of topics assigned to it. At Notre Dame we have adopted the expedient of devoting a third semester to topics which might be called "modern physical chemistry." In addition to subjects such as atomic and molecular structure, this course also includes approximately eight lectures on nuclear physics and chemistry. Obviously, this brief treatment can do no more than state the bare essentials. The main topics are the production and properties of unstable nuclides and the application of these phenomena to the study of chemical processes. We hope at least to leave the student with some appreciation of the significance and scope of the methods, if not with its details.

UNDERGRADUATE LABORATORY INSTRUCTION

Experiments in nuclear chemistry appear in both of our undergraduate laboratory courses in physical chemistry. In the first course, one afternoon's work (out of a total of twelve afternoons) is performed by every student. This work consists of a study of counting operations, including plateau determination, statistical fluctuations, and absorption of beta radiations. The decay of 25-minute I^{128} is also observed.

The second semester of physical chemistry laboratory includes three to five additional periods of nuclear chemistry, depending on the student's inclinations. Additional counting considerations, such as scattering and dead-time losses are studied. Growth of 56-minute In^{116} in neutron bombardment and the complex decay of bromine activities are observed. In addition several experiments on exchange reactions, using active iodine, are performed. These experiments have been described in detail in previous communications.[3]

This laboratory work has been specifically designed for use on the undergraduate level and the investments of time and money have been minimized. One of the unique features of the work is the use of a 5-mg. Ra-Be neutron source to activate samples for student work. Among the advantages of this procedure is the ability to use short-lived activities. This permits activation and decay within a single laboratory period and reduces the problem of contamination of laboratory equipment. The health hazard associated with the use of such a small source is very small and the neutron flux obtained is of course comparably small. However, direct activation of substances of high cross section, such as indium and gold, is quite feasible and activation of several other elements may be accomplished through use of the Szilard-Chalmers reaction.[4]

It seems inevitable that experiments of this type will find increasing use in undergraduate physical chemistry laboratory courses. We feel that those suggested are appropriate to the advanced undergraduate level of instruction. No large proportion of our undergraduate or graduate student body may be expected to find employment in the atomic energy industry but, on the other hand, many of them will probably have occasion to use or evaluate the applications of nuclear chemistry. Many potential users of these techniques will be created simply by imparting the most rudimentary knowledge to the greatest possible number of students. The time may soon come when the Geiger counter is as common as the electronic pH meter, and certainly many aspects of its use are no more involved.

Graduate instruction and research in nuclear chemistry continues to operate at a high level in many schools, drawing on the fund of talent and knowledge accumulated on the various atomic energy projects. However, there exists an unfortunate tendency to regard the field as highly specialized and difficult in all its

[3] WILLIAMS, R. R., JR., W. H. HAMILL, AND R. H. SCHULER, J. CHEM. EDUC., **26**, 210, 310, 667 (1949).

[4] WILLIAMS, R. R., JR., W. H. HAMILL, AND R. H. SCHULER, *ibid.*, **26**, 667 (1949).

aspects. This is intensified by the confinement of the instruction to the graduate level. It seems to us that some effort must now be made to integrate elementary aspects of this work into our undergraduate programs. This will require not only the efforts of the teachers of nuclear science but also cooperation from their colleagues and the various university, governmental, and manufacturing agencies which aid and service the teaching profession. The possible benefits of such a program are obvious and general.

NUCLEAR CHEMISTRY AT THE UNIVERSITY OF CALIFORNIA

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Now and again in the evolution of science a new field of study emerges. It is usually neither possible nor important to point out a particular day or year in which the new branch was born; instead, reflection will show that it took root in a number of existing branches and grew along with and finally away from its parents. As the body of knowledge expands in breadth and depth the aggregate techniques and concepts require longer periods of time to master and become a subject for specialization. Such, in our opinion, is the body of knowledge and field of study which we choose to call nuclear chemistry.

It is perhaps easiest to envisage the scope of nuclear chemistry in terms of the ways in which a person with broad basic background in chemistry can effectively contribute to the study of nuclear phenomena and in terms of the training which a chemist will find advantageous in utilizing the tools provided by nuclear phenomena in the solution of many chemical problems. It is the aim of this paper to provide a discussion of these subjects, in particular the present method of operating our laboratories and teaching at the University of California.

In attempting to define nuclear chemistry it should first of all be realized that this same term may refer to quite different studies in different laboratories. Such differences are not unique to this field but are common to all. An inorganic chemist in one place may be interested in analytical problems, another in reaction kinetics. Similarly, in one laboratory a nuclear chemist may be studying the behavior of minute amounts of material which can be followed by virtue of their radioactivity, while another nuclear chemist is primarily concerned with the interpretation of nuclear reactions and uses the first chemist's work to identify the products of these reactions. The first chemist is engaged primarily in a special kind of analytical problem, the second in studies which in many quarters would not be called chemistry at all but nuclear physics. We shall spend some time discussing the chemist's position in this latter field; whether it is called chemistry or physics has no more relevance than an abstract discussion of whether spectroscopy is chemistry, physics, or astronomy. It is more profitable in the case at hand to discuss what chemists are doing. This is the basis which we use for defining the field of nuclear chemistry. At present then nuclear chemistry would be the study of nuclear reactions and the associated chemical studies needed to elucidate these reactions or which take advantage of nuclear reactions.

The use of chemistry in nuclear studies has an early history. Soon after the discovery of radioactivity, the observation that pitchblende has higher specific radioactivity than uranium was the stimulus for chemical fractionation of the ore. The chemical separations by the Curies which resulted in the discoveries of polonium and radium called for a distinctive type of chemistry which has ever since been an earmark of the chemical phases of nuclear chemistry. This characteristic feature has to do with chemical operations on invisible amounts of material—invisible in all respects except to instruments and materials which can detect radioactivity. Almost all of the natural and artificial radioactivities are encountered in "weightless" concentrations and the special type of analytical chemistry which has evolved to cope with these quantities has been termed

radiochemistry which we now consider as a branch of the broader field *nuclear chemistry*. The methods of radiochemistry already well established twenty and thirty years ago were used in the laboratory investigations of the natural radioactivities and industrially for radium separation. The discovery of artificial radioactivity and the development of accelerators for inducing radioactivities in all of the elements greatly widened the scope for radiochemical investigations. During the past war these methods became of vital importance in extracting plutonium from uranium and fission products, and the development of the complex process which resulted was by far the most extensive use yet made of such methods. Research and development chemists numbering in the hundreds worked with techniques and instruments known previously only to a handful of research workers. From their results were built huge chemical plants costing over $100,000,000 while the maintenance and extension of this program now employs more chemists than during the war.

Radiochemistry, which has been defined as the study of substances at extreme dilutions made possible by measurement of the radioactivity, is a rapidly expanding field with rapidly increasing numbers of uses in research and industry. The tracer method and its manifold applications is destined to become more and more widely used as the availability of radioactive materials and the training of potential users permits. The applications of tracers to the solution of problems in chemistry, biology, and other fields are, of course, not included in our definition of nuclear chemistry. It should be pointed out before turning to another subject that radiochemistry is based on a fundamental knowledge of chemical behavior such as solubility properties, surface chemistry, and reaction kinetics, to name but a few phases. It is basically a chemical field in which nuclear instruments play the secondary role of permitting one to follow the radioactivity through the chemical separations.

A natural consequence of the ability to separate radioactivities is that complex mixtures may often be resolved into simple pure radioactive species. Indeed, as we shall see, this is the goal for the radiochemical separations when we wish to prepare simple mixtures or pure radioactive species for study of their nuclear properties. This brings us to the discussion of a large and fruitful outlet for the nuclear chemist which has led him far afield from what we used to consider chemistry and into the forefront in the development of many aspects of nuclear theory. Many examples of this work would be necessary to properly describe its scope, but only a few can be given here. One aspect has to do with the discovery of new nuclear phenomena by identifying the products of nuclear reactions. One of the most astounding discoveries made by this method was that of nuclear fission in which the identification of certain fission products by radiochemical methods led to the interpretation of the reaction. It may be argued that fission could have been discovered by some other technique, for example, measurement of the large electrical pulses in an ionization chamber. However, there are many studies which can best be pursued by chemical methods and some in which they are indispensable. In particular, the last few years have seen developments in which there can be little progress without employing chemical separations. The new high energy range of accelerated particles is producing such complex mixtures of reaction products that it is hopeless to attempt to diagnose the reactions without chemical separations. In a single irradiation with particles in the 100-Mev range thirty or more recognizable radioactive species may be formed, that is, they are recognizable if they are first fractionated into the fifteen or so elements of which they are isotopes. To make these separations with speed and still obtain in most cases extremely high purity is a first-class analytical job requiring a good knowledge of inorganic chemistry and the special skills of radiochemical methods. Once the separations have been made, the radioactivities identified, and their yields measured, one may then begin to piece together the nuclear reactions which produced these products and obtain information as to what happens when nuclei are excited to extremely high energies.

These examples which could be expanded greatly indicate how the nuclear chemist uses chemistry to obtain information on nuclear reactions that have occurred. Sometimes the objective is somewhat different but still in the direction of studying nuclear phenomena. During the past year, for example, several in our laboratory have become interested in extending our knowledge of alpha-radioactivity. This was made possible by the newly acquired ability to produce many new alpha-particle emitters by making use of the high energy cyclotrons and the nuclear reactors or piles. Many new techniques in chemical separation and radioactivity measurements were developed for these studies. The interest in alpha-radioactivity is several-fold. By means of a large amount of alpha-decay data we are able to reconstruct the energy relationships of the whole heavy element region; that is, it is possible to construct an energy surface in a thermodynamic sense relating the nuclear binding energies of all parts of this region. Secondly, by using the quantum mechanical treatment for the alpha-decay process we were able to make some fundamental changes in alpha-decay theory and to calculate in a meaningful fashion the nuclear radii in this region. Certain abrupt changes in nuclear radius are furthermore interpreted, along with changes in alpha-energy, in terms of regions of great nuclear stability. We have outlined this particular study as it illustrates rather well the information which can be obtained by characterizing radioactive properties of a large class of nuclides and that the most powerful tool for examining these radioactivities involves a great deal of chemistry.

There is another major branch that we include in nuclear chemistry, and this consists of chemical investigations of the synthetic and rare radioactive elements. The unique features of this work are that at least up to now the investigator must obtain or recover his own

starting material by radiochemical methods; the chemical experimentation is either on a micro or ultramicro scale, and the experimentation is beset with the peculiar difficulties of working with intensely radioactive substances. While much information on chemical properties can be obtained on the tracer scale, there are broad classes of measurements which can only be made at macro concentrations or with the pure element and its compounds. Thermodynamic properties and physical properties of the metallic state and its compounds, absorption and emission spectra and certain nuclear properties fall into this category. Even in the case of properties which can be deduced by radiochemical methods exact measurements can only be made with the element in macro concentrations. For example, we may get approximate values for solubilities and oxidation potentials with only tracer amounts of material, but accurate values can only be obtained by more conventional chemistry. The importance of determining the chemical and physical properties has led to the isolation of all of the synthetic and rare radioactive elements for which there can be any hope of obtaining in pure state. Only radium and protactinium (elements 88 and 91) had been isolated before the war, but since 1942 technetium (43), promethium (61), polonium (84), actinium (89), neptunium (93), plutonium (94), americium (95), and curium (96) have all been seen and worked with in the pure state. Two other elements, astatine (85) and francium (87), have no isotopes of sufficient half-life to permit preparation and isolation. Obviously the isolation within the last few years of eight new elements (to be sure of limited availability at present) opens up wide new areas for study. There are two great difficulties with this work, however. First, the limited availability of most of these elements makes it mandatory to work on a milligram and even microgram scale. The ultramicrochemical techniques which have now been brought to a condition of general usefulness have become an earmark of this branch of nuclear chemistry. The other difficulty is the intense radiation associated with even micrograms of almost all of these elements, making necessary special techniques, and in some cases remote-control equipment is necessary.

The foregoing explanation of what we include in nuclear chemistry was indulged in as it will help give reason for the subject matter of our lecture courses and serve as a background for outlining the research program in our laboratory.

Two lecture courses in nuclear chemistry are offered in the Department of Chemistry, one each semester. The first is a two-hour course with an undergraduate number designation although up to this time about two-thirds of those enrolled have been graduate students. The object of this course is to provide a descriptive survey of nuclear theory and methods including an introduction to radiochemical methods and properties of radiation. The students who take this course apparently do so for a number of reasons. The largest single group consists of graduate students who expect to take part in some phase of nuclear research or are already doing so. This group includes chemists in nuclear chemistry, physicists, and a wide variety of students in the agricultural and life sciences. Other students take the course as an elective presumably with nothing more in mind than to become acquainted with a new and interesting field.

The subjects covered in the undergraduate course start with an historical development and the current picture of nuclear structure including nuclear forces, conditions for stability, and a qualitative nonmathematical treatment of the quantum mechanical properties. This is followed with a description of the radioactive decay processes, the theories of beta- and alpha-decay, and the properties of the radiation. Induced nuclear reactions are next treated, and this subject includes reactions with charged particles and neutrons, and the instruments which produce them as well as the factors which govern yields. Special reactions like the fission process and the nuclear chain reaction are also dealt with. A brief survey of radiochemistry then follows in which no attempt is made to develop a system of analysis, but the principles of separation and identification of radioactivities from irradiated or naturally occurring substances are outlined. Other subjects treated are the chemical and physical effects of radiations on matter, which is termed *radiation chemistry*, a survey of the natural radioactivities, and the chemical properties and place in the periodic system of the new synthetic elements.

In general, we have attempted in this course to give students with a background in chemistry a feeling for the nature of nuclear reactions and to indicate some of the things which chemists can do in the field.

The graduate lecture course given the second semester is aimed more specifically for graduate students engaged in nuclear work. The outline of the subjects covered in this course is not greatly different from that already mentioned for the undergraduate course. There are two major differences, however. In the advanced course we build upon the descriptive picture given in the elementary course and give a more rigorous treatment and a great deal more detail. Secondly, since this course is primarily for those engaged in research we make a determined effort to keep it strictly up to date by the inclusion of appropriate new work which comes out almost week by week. Other differences in this course are: (1) a more detailed treatment of radiochemistry including specific reactions for all of the elements, (2) a brief survey, for the student's general interest, of current ideas on such subjects as astrochemistry, cosmic rays, and meson theory.

In the graduate course we also require each student to prepare a review paper on a subject of his own choosing. This has the important purpose of acquainting him with the original literature and also testing his abilities for discrimination and correlation. It may be mentioned that a number of the graduate students even at this early stage in their careers prepare very creditable papers which with minor editing would probably conform to the standards of the reputable journals.

It may be well to indicate why we offer no formal laboratory course in nuclear chemistry. At the present time such a course would be of value only to a small minority. For graduate students in nuclear chemistry the policy of the department is to begin research the first semester, and the facilities and instruction by the research directors and staff members of the Radiation Laboratory are much better than could be provided in a formal course. Many of the other graduate students are likewise doing research in other departments, and besides this the medical physics division of the physics department does offer a course in radioactive measurements. Finally, the research laboratories are open to qualified undergraduates who can thus obtain better instruction and have access to better facilities than they could in a formal course. The chemistry department does offer an instruments course in which radiation-counting equipment is one type which students are taught to understand and use.

It may be mentioned that the physics department gives nuclear physics as two courses, one undergraduate and one graduate, and also offers no formal laboratory courses for physicists. For advanced students doing nuclear research there is also given in the chemistry department a seminar which meets weekly and the physics department similarly has a nuclear seminar which a number of chemists attend. Other special meetings such as those held by the Radiation Laboratory are open to qualified students.

The research program for graduate students in nuclear chemistry at the University of California is of considerable breadth and probably differs in a number of respects from that at other schools. First of all, an explanation may be in order for the functions of the Radiation Laboratory and Department of Chemistry in the training of graduate students. All students in nuclear chemistry are enrolled in the Department of Chemistry and must satisfy the entrance requirements, pass the examinations, take the courses, and otherwise fulfill all of the requirements demanded of any other chemistry graduate student for an advanced degree. The degree when obtained is accordingly granted in chemistry by the Graduate Division of the University. The Radiation Laboratory on the other hand, is an organization which offers no formal instruction and gives no degrees, but provides research facilities for its own staff members and for the departments of the university. Most of the senior staff members of the Radiation Laboratory are also members of one of the several departments such as physics, chemistry, medical physics, and engineering. The graduate students may either hold teaching assistantships in the Department of Chemistry or part-time research positions in the Radiation Laboratory, which are in essence research fellowships. However, all students are expected to do some teaching during their graduate years.

An entering student may select any of a large variety of subjects for his research. Those interested primarily in the application of tracers may, as an example, elect to work with Professor M. Calvin on bio-organic studies such as C^{14} work on photosynthesis, or with Professor R. E. Connick, whose main fields of interest are reaction kinetics and complex ion formation. On subjects somewhat closer to nuclear work, Professor B. B. Cunningham is primarily concerned with the chemistry of the transuranium and rare earth elements and is the authority on the ultramicrochemical methods used in these chemical studies and some nuclear studies. Professor D. H. Templeton, besides carrying on nuclear research with the accelerators, operates a laboratory for X-ray diffraction studies of crystal structure which he applies to the synthetic elements and to other purposes. Another member of the staff is Dr. K. Street, Jr., who works on nuclear properties and solution chemistry of the transuranium elements. Most of the graduate students of the authors of this paper work on nuclear transformations with the large accelerators, but some conduct in addition strictly chemical studies in the heavy element region. The group as a whole operates, with a small permanent staff, a number of specialized facilities and instruments which the students use as they apply to their problems. These include special facilities for handling strongly radioactive material. In this connection we should mention the radiation protection or Health Chemistry group of the Radiation Laboratory, under the direction of Mr. Nelson Garden, which has done an excellent job in virtually eliminating the hazards of radiation primarily by providing proper equipment, but in addition it handles the monitoring and supplementary services. Besides the so-called "hot laboratories" there are a number of major equipment pieces for nuclear measurements including special alpha-particle counters, beta-ray spectrograph, mass spectrograph, coincidence counting equipment, and others. Also, as a service the Laboratory runs a spectrographic laboratory which is used both for analysis and for special research problems which demand this type of equipment.

In closing this discussion of the graduate student training in nuclear chemistry we can best illustrate the types of work which the students do by listing some thesis titles of recent Ph.D. graduates. Some of these are as follows:

Nuclear and Chemical Properties of Americium and Curium.
High Energy Spallation Products of Copper.
Characteristics of Bismuth Fission with High Energy Particles.
Neutron Deficient Isotopes in the Rare Earth Region.
Isotopes of the New Element Curium.
Equilibria in the Oxide Systems of Praseodymium and Americium.
Thermochemical Studies of Oxides of Praseodymium and Americium and the Estimation of the Pr(III)-Pr(IV) and Am(III)-Am(IV) Potentials.

It should be pointed out that students handling these and similar problems need not have had any previous acquaintanceship with nuclear work and that some excellent work has been done by students who received their undergraduate training at small schools. In some cases the undergraduate training in these schools has been good and in others the students had a great deal of native ability which allowed them to learn rapidly.

TEACHING RADIOCHEMISTRY AT MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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THE DEVELOPMENT OF RADIOCHEMISTRY

It is just fifty years from the discovery of radioactivity by H. Becquerel (1895) to the detonation of the first atomic bomb (July 16, 1945). But only three-fifths of this period was required for the development of atomic physics from the discovery of the electron (W. Crookes and J. J. Thomson, 1895) and the X-ray (W. C. Röntgen, 1895), through the work of M. Planck, A. Einstein, N. Bohr, and A. Sommerfeld to the Minerva-like birth of the quantum mechanics (E. Schroedinger, P. A. M. Dirac, W. Heisenberg, 1925). Because radioactivity was discovered by physicists and the chemical aspects were exploited effectively by them, and because the work was related to and overshadowed by atomic physics, nuclear chemistry has not until this decade received a fraction of the attention it deserves from the chemical fraternity.[1]

Before we go much further in a discussion of nuclear chemistry and radiochemistry, a few definitions are in order. Nuclear chemistry deals with the chemical aspects of nuclear transformation, of the separation and study of nuclear species (stable or radioactive), of radioactive decay, and the use of nuclides[2] as tools in chemical research.

Chemical work with nonnatural mixtures of isotopes, or interpretations of deviations from the norm in nature (of great interest in geochemistry and in chemical cosmogony) are principal parts of the subdivision of *isotope chemistry*. According to the latest tabulation (*1*), 272 stable nuclear species are found in nature, together with 10 very long-lived species that can be handled as if stable. The number of radionuclides known is over 700 at the present date. Chemical work with radioactive materials comprises the subdivision of *radiochemistry*. This is the chemistry of the production, isolation, and identification of radionuclides, including tracer analysis, tracing, and chemical studies of phenomena associated with nucleogenesis (hot atom chemistry). Marie Slodowska Curie founded radiochemistry in her search for radium, and at the same time founded its engineering analogue *radiochemical engineering*, on which the radium-mesothorium-polonium industry rests. Chemical problems associated with the interactions of high-speed particles and high-energy electromagnetic radiations with matter make up the field of *radiation chemistry*.

Isotope chemistry is limited to the 61 elements with two or more stable or near-stable isotopes found in nature. Natural radioactivity of uranium and thorium provides us with six more transitory elements (polonium, radium, actinium, radon, protactinium, and francium), which were found and characterized with the techniques of radiochemistry. These were first developed by Mme. Curie in 1896 and later extended by A. Debierne, G. C. Schmidt, Soddy, Rutherford, F. Paneth, Hevesy, S. Meyer, K. Fajans, Hahn, Lise Meitner, F. E. Dorn, and others in the next 20 years, including in the United States, H. N. McCoy, R. B. Boltwood, H. Schlundt, and S. C. Lind. Transitory species in the natural radioactivity families furnish also tracers for thallium, lead, bismuth, and thorium.

With the discovery of nuclear transmutation by Rutherford in 1918, followed by the development of the electronuclear accelerators of J. D. Cockcroft, R. J. Van de Graaff, and especially of the cyclotron of E. O. Lawrence (1932) and the discovery of artificial radioactivity by the two Joliot-Curies (1934), science was presented with a flood of synthetic radionuclides, with useful radioisotopes of all of the 81 stable elements, and all other elements up to and including plutonium. The slowness of chemists to participate even in the study of the many accessible synthetic elements is illustrated by the very few papers by chemists challenging the fantastic structure of claims in 1934–1939 for

[1] The Nobel Prize Committees have frequently honored nuclear physicists with Nobel Prizes in Chemistry: E. Rutherford (1908), M. S. Curie (1911), F. W. Aston (1922), and F. and I. Joliot-Curie (1935). Nuclear chemists have also been rewarded by the committee: F. Soddy (1921), H. C. Urey (1934), G. Hevesy (1943), and O. Hahn (1944). For the complete picture in nuclear science to date, we may add the names of the prize winners in Nuclear Physics: H. A. Becquerel, P. Curie, and M. S. Curie (1903), A. H. Compton and C. T. R. Wilson (1927), J. Chadwick (1935), V. F. Hess and C. D. Anderson (1936), E. Fermi (1938), E. O. Lawrence (1939), P. M. S. Blackett (1947), H. Yukawa (1948), C. F. Powell (1949), and that of one radiobiologist prize winner in Medicine, H. J. Müller (1946). In the judgment of these Committees, nuclear chemistry has not been set apart from nuclear physics.

[2] The word *isotope*, as defined by F. Soddy (*2*), is applied to one of several nuclear species of the same nuclear charge (proton number) but different mass number, occupying the same place (ἴσος τόπος) in the periodic system. Nuclear isomers, of the same proton number Z and neutron number N, and thus the same mass number A, are known; these differ only in quantum numbers and energy contents. T. P. Kohman (*3*) has introduced the word *nuclide* for "a species of atom characterized by the constitution [and energy] of its nucleus." Note that the chemist works with nuclides, not with bare atomic nuclei, and that the word isotope is often misapplied in the newspaper-dominated world.

transuranic elements. The world-shaking discovery of the fission reaction was made, however, by the most difficult path—the chemical one—by O. Hahn and F. Strassmann (*4*) in 1938 in Berlin, after an honorable failure by Mme. Joliot-Curie and P. Savitch (*5*). The profusion of cyclotrons, especially in the United States, had, however, given impetus to the spread of radiochemistry among physicists, to the training of cyclotron radiochemists, and to the orienting of medical workers to the utility of radioactivity in research and therapy. The chief centers in this country were at the University of California at Berkeley (where seven synthetic elements were destined to be synthesized), Chicago, Purdue, Michigan, Rochester, Princeton, Columbia, Yale, Harvard, and M. I. T.

On Dec. 6, 1941, work on all aspects of nuclear energy began in great earnestness (*6*, *7*, *8*) and the tasks and prospects of radiochemistry and isotope chemistry, in all their ramifications, commanded the attention under strict cover of thousands of chemists and chemical engineers. Except for a relatively few pre-fission radiochemists,[3] most of the workers in the field in this country received apprenticeship at one of the war laboratories or at their successors under the Atomic Energy Commission.

Because of the existence of a vigorous national program in research in nuclear science, associated with government-sponsored military and industrial development, employment prospects in nuclear chemistry have been, and promise for a long time to be, excellent. If one considers the effort spent, however, in research in nuclear physics, and in applications of radiotracer chemistry in the natural sciences and in applied fields like metallurgy, research medicine, and medical diagnosis and therapy, it will be seen that chemists in this country are still backward in nuclear chemical research, as they were in the pre-cyclotron and pre-fission days.

NUCLEAR CHEMISTRY AT M. I. T.

The end of World War II found Massachusetts Institute of Technology, with the authors as senior staff members, representing the interests of nuclear chemistry and its relations to inorganic and general chemistry, and with the Institute prepared to launch a strong program on all fronts of nuclear science and engineering not involving classified work. There had been a broad program in nuclear physics before the war, with a legacy of an operating 42-in. cyclotron, several Van de Graaff machines, and many physicists appreciative of the problems of nuclear chemistry. The applied radioactivity work carried out under the general direction of Prof. R. D. Evans in the Radioactivity Center had led to the infection of many departments with an interest in tracer techniques, and had been the basis for much intensive cooperative work with groups in various Boston hospitals.

The evidence indicated that the nuclear chemistry work ought to be integrated well with the chemistry department's program, especially that in inorganic chemistry, that it should be taught with the minimum of physics necessary to make it understandable, and that the course work should be oriented first toward the chemical and the applied side to be of benefit to general chemical research and to research workers in engineering and medicine.

Nuclear chemistry is taught today in several channels. Two lectures are given to the first year chemistry course (Course 5.01 taken by all M. I. T. students), one with demonstrations of the effects of α, β, and γ radiations, neutron activation, and half-life (30*s* Rh^{106} separated by water extraction from Ru^{106} as ruthenium tetroxide in carbon tetrachloride). A senior-graduate course in instrumental analysis (Course 5.15, taught by Profs. D. N. Hume and L. B. Rogers) contains a major experiment in radiochemical assay and Geiger-counter behavior. An introduction to nuclear structure, radioactivity, and to the chemistry of the synthetic elements is given in the required senior course in inorganic chemistry (Course 5.061 of Prof. W. C. Schumb).

The graduate students in nuclear chemistry and those in physical, analytical, and organic chemistry who are using radiochemical techniques all report their researches in the appropriate graduate research seminars in inorganic, physical, analytical, and organic chemistry. Indeed, there are three autonomous groups of staff and graduate students with major emphasis on radiochemistry, namely the inorganic-nuclear chemistry group (Coryell-Irvine), the analytical group with emphasis on the analytical chemistry of the fission product elements (under Profs. D. N. Hume and L. B. Rogers), and the organic radiochemistry group specializing in tracer studies of organic structures and reaction mechanisms (under Prof. J. D. Roberts). These groups contain in aggregate about 10 senior students doing experimental B.S. thesis work, about 25 students doing Ph.D. thesis work, about seven post-doctoral fellows, and about five technical assistants. In addition, radionuclides are used as an important research tool by three or four other research groups in physical and organic chemistry in the department and by numerous groups in metallurgy, food technology, mechanical engineering, and biology.

The Institute founded in 1945 an interdepartmental facility known as the Laboratory for Nuclear Science and Engineering under the directorship of Prof. J. R. Zacharias of the physics department. The associate director is Prof. E. R. Gilliland of chemical engineering, and the administrative head is Mr. M. M. Hubbard. This body acts as a central agency for supporting activities in nuclear science, for providing for the construction and maintenance of heavy equipment, and for fostering active collaboration among the research staffs of many departments. At the present date,

[3] The Berkeley groups have had such an important role that it may be useful to name the radiochemists prominent there by 1941: W. F. Libby, M. D. Kamen, S. Ruben, G. T. Seaborg, E. Segrè, J. W. Kennedy, A. C. Wahl, G. Friedlander, I. L. Chaikoff, I. Perlman, D. C. DeVault, R. W. Stoughton, S. G. English, M. L. Perlman, W. E. Cohn, and H. S. Brown.

support is considerable in the departments of physics, chemistry, electrical engineering, and chemical engineering, where interests interlock in a program for nuclear engineering as well as for nuclear science.

Many chemistry students, undergraduate and graduate, take as electives the junior physics courses in atomic physics (Course 8.05, Prof. H. Mueller) and introductory nuclear physics (Course 8.06, Prof. M. Deutsch), and all take chemistry courses in atomic and molecular structure (Course 5.67, Prof. R. C. Lord, or Course 5.75, Prof. L. Harris) which prove to be valuable background for nuclear theory. The majors in nuclear chemistry take, after the radiochemistry course described below (Courses 5.09, Radiochemistry, and Course 5.091, Radiochemistry Laboratory), several more of the eight graduate courses in nuclear physics, especially one on neutron physics and nuclear engineering (Course 8.57, Prof. C. Goodman). This last course is the basis for the development of the well-known reviews of nuclear science and engineering edited by C. Goodman (*9*).

When the number of students with central interest in radiochemistry is larger, it is hoped to introduce advanced colloquia in nuclear theory for chemists and in radioactivity in chemistry.[4] The research interest of the graduate students seems to fall about equally in the two classes of interest.

Several of the engineering departments of M. I. T. are encouraging their students to take electives in nuclear science as a preparation for adaptation to the applied fields of atomic energy. The Institute has for two years been operating a practice school jointly among the three operating plants in Oak Ridge (the diffusion and the electromagnetic isotope separation plants, and the pile-radiochemical engineering plant at the Oak Ridge National Laboratories) where qualified graduate engineering students with AEC security clearance receive 22 weeks experience in industrial nuclear operations. This Oak Ridge Practice School, under the direction of Prof. J. E. Vivian, is having a profound effect on the development of nuclear trends in engineering circles.

Like most of the universities of the country, M. I. T. is associated with the research-training program of the Atomic Energy Commission's National Laboratories, being officially affiliated with the Brookhaven National Laboratory as an active member of the Associated Universities, Inc. This bond has been very important at the faculty level, and with the start-up of the large Brookhaven pile Aug. 22, 1950, and the completion of the Hot Laboratories, it is anticipated that fruitful exchange will occur at the graduate student level. Present hopes to have an unclassified face at the pile and to retain an unclassified area in the Hot Laboratory make the prospects much more attractive for us and for all other research institutions in the Northeast.

[4] Probably based on A. C. WAHL AND N. A. BONNER, Editors, "Radioactivity Applied to Chemistry," John Wiley and Sons, New York, scheduled for appearance in 1951.

LECTURE MATERIAL IN RADIOCHEMISTRY

The department of chemistry has two courses in radiochemistry intimately interrelated. These are Course 5.09, Radiochemistry, with three hours of class and three hours of preparation a week for one semester (6 units), and Course 5.091, discussed in the next section, with three hours of laboratory a week (3 units). The lecture course may be taken without the laboratory course but the laboratory background is retained by detailed discussions of the laboratory experiments in one lecture each week. The pair of courses is offered in the fall semester, and it is open to outstanding seniors in chemistry and physics, and to graduate students who have had physical chemistry laboratory and who have had or are taking advanced inorganic chemistry.

Two outstanding new text books are used for the course, that by Friedlander and Kennedy (*10*) and that by Williams (*11*). Because of the requirement that laboratory work start in the second week of the course the lectures start with Chapter VIII of the first text and the students receive reprints of a general introduction to radiochemical measurement (*12*) and reading assignments in R. D. Evans' chapter 1 of the Goodman volume I (*9*).

The order of presentation of lecture material is given in Table 1, together with references to topical papers that are stressed in the course. Numerical problems are assigned nearly every week and discussed at the lecture on laboratory work. The problems are chosen to emphasize chemical aspects of nuclear chemistry or applications to chemistry or to the laboratory of the lecture work (reactions and equilibria involving transitory or synthetic elements, decay properties of unknown nuclides, counter efficiency, separations of species in cyclotron targets). The students are encouraged to explore the broad possibilities in research of the problems and to experiment with the techniques of intelligent estimation and the best methods of computation. Four examinations of one hour each are given in the course. In some terms a paper is required of the student covering the nuclear and chemical requirements for the solution of a laboratory problem in applied radiochemistry in a field of his interest.

An effort is made to draw to the student's attention many of the important papers of recent date that represent new landmarks in a fast-changing field. Some of these are unclassified reports or declassified documents (MDDC or AECD)[5] from the Manhattan Project or the various National Laboratories of the Atomic Energy Commission. Others (*20,25,26*) represent major collections of research papers or survey papers of the National Nuclear Energy Series, a useful collection of information from the wartime work of the Manhattan Project, about half of which is now in print.[6]

[5] Obtainable from the Technical Information Branch of the U. S. Atomic Energy Commission, P. O. Box E, Oak Ridge, Tennessee.

[6] The National Nuclear Energy Series, in eight divisions, is published for the Atomic Energy Commission by the McGraw-Hill Book Company, New York.

The remainder of the literature references of Table 1 represent papers that go into some detail about subjects pertinent to the interests of the instructors of the course. Part of the philosophy of this course is that nuclear chemists should follow their own interests, since the field is the crossroads between well-organized nuclear physics and the large variety of fields in engineering, biology, and medicine where radiochemistry is an analytical tool.

TABLE I
Sequence of Topics in the Radiochemistry Course

Topic	*Reference*
The Fundamental Particles	Current magazine articles[a]
The Nucleus	Evans in (*9*)
Spontaneous Nuclear Transformation (Radioactive Decay)	
Interactions of Radiation with Matter	Coryell (*12*), Glendenin (*13*)
Instruments	
Natural Radioactivity and Geochemical Problems	Joliot-Curie (*14*)
Laws of Growth and Decay	Special Notes
Nuclear Stability	Special Notes, Brightsen (*15*)
Nuclear Transformation and Electronuclear Machines	Irvine (*16a, 16b*)
Counting Statistics	Jarrett (*17*)
Fission and the Pile	Coryell (*18*), Irvine (*19*)
The Fission Products	Coryell and Sugarman (*20*)
The Nuclear Energy Industry	Goodman (*9*)
Ion-Exchange Separations	Cohn, Parker, and Tompkins (*21*) Tompkins (*22*), ACS Symposium (*23*)
Synthetic Elements, Heavy Element Chemistry, and the Periodic System	Seaborg (*24, 25, 26*)
Radiochemical Separation; Laws of Carrying	Special Notes
Chemical Effects of Nuclear Transformation (Hot Atom Chemistry)	Libby (*27*), Edwards and Davies (*28*)
Electron Transfer	Lewis (*29*)
Gamma Rays, X-rays, Critical Absorption	DeVault (*30*)
Isotope Chemistry	
Applied Radiochemistry and Tracer Chemistry throughout the Periodic System	

[a] Authoritative papers on fundamental particles have occurred, for instance, in *Scientific American* (G. W. Gray) June, 1948; *Physics Today* (R. P. Feynman) June, 1948; and *Life*, Oct. 10, 1949.

LABORATORY EXPERIMENTS IN RADIOCHEMISTRY

The laboratory work in radiochemistry is offered as a separate course in order that students from other departments can take the lectures for credit without the laboratory. This division is arbitrary and does not reduce the close interrelation between the two courses. Three hours a week are assigned to laboratory work although it is admitted that the students find it necessary to devote some more time for preparation and report writing.

Experiments are designed to lead the student gradually through the elementary physical principles of detection and measurement of radioactivity, radioactive decay and chain relationships, β-ray energy measurements, and qualitative analysis of β spectra, into the chemical problems of fission, activation, nuclide separation, and the behavior of ions at low concentrations. One experiment is devoted to the measurement of γ-ray energies. An outline of the experiments performed is given in Table 2.

The first experiment requires quite an array of radioactive materials, all but Sr^{90} being borrowed, together with all available survey instruments for familiarization and calibration. In Experiment 2, the students prepare a personal reference β-standard from lead foil containing Pb^{210}, and study the separation and counting of Bi^{210} from another sample.

The last three experiments (10, 11, and 12) are optional at the present time. They allow the student with advanced interests an opportunity for additional work. New experiments will be added to this group, and as experience dictates they will be moved up into the required group as additions or substitutions.

Electronic equipment for the course consists of six Geiger-Mueller (G-M) counters and scaling units. Four of these are research equipment but are reserved mostly for course use two afternoons each week for most of the term. The counters are commercial units from various manufacturers housed in standard shields as described elsewhere (*12*). The scalers are simple binary scale-of-128 constructed in the electronic shop of the Laboratory for Nuclear Science and Engineering.

Three Lauritsen electroscopes are used in the standard manner (*12*). They all have thin aluminum windows for β-ray measurement. A G-M flow-type counter with sample holder inserted is available and is used for the measurement of very soft β-radiation. A scintillation counter assembly is under construction. This is a flexible unit designed for α, β, and γ-ray counting. Integral and differential pulse height discrimination will be possible with the equipment.

Survey meters and personnel monitors are provided by the Health Physics Division of the Medical Department of M. I. T. The students wear radiation meters only when working with the neutron source or at the cyclotron. The development of the responsibility of each radiochemist to himself, his colleagues, and to his instruments and experiments is made a cornerstone of the teaching. Since the Geiger-Mueller counters are more sensitive by a factor of far more than a thousand to activity than is a living organism,[7] personnel are automatically protected by the precautions that lead to reliable measurement. In the five years of our experience no case of significant personnel contamination or no case of serious contamination of counters or absorbers has occurred. The counting room is separate from the laboratory, and no uncovered sample may be brought into it.

Radioactive material needs for the laboratory course are not large. Estimates of these needs are given in

[7] A γ-radiation field giving 6 milliroentgens per hour (a conservative current value for the maximum permissible dose for an 8-hr. day) will give over 300 counts per second in an ordinary Geiger-Muller counter.

Table 2. As can be seen, natural radioactive sources and radionuclides obtained from the Isotopes Division of the AEC constitute the bulk of material used. A good neutron source of some type is necessary for some of the experiments. The chemistry department owns a Ra-Be neutron source containing approximately 100 mg. of radium. Advantage also has been taken of a 1-g. Ra-Be source rented by one of the physics re-

TABLE 2

Outline of Experiments for the Radiochemistry Laboratory

No.	*Title*	*Objectives*	*Radioactive material for 12 students*	*Special equipment*
1	Health Physics Instrumentation	Use of personnel monitors Calibration of survey meters Verification of inverse square law Measurement of β-ray scattering Comparison of relative α- and β-ray ionization	Four radium standards, 1 to 25 mg. Co^{60} source ~0.5 mc. Two Sr^{90}-Y^{90} β-ray sources ~10 μc. Pb^{210} source 0.5 μc. in equilibrium with Bi^{210} and Po^{210}	Pocket ionization chambers, film badges (wrist type), survey instruments (electroscope, electrometer, and G-M counter types)
2	Introduction to Techniques of β-ray Counting	Use of the Geiger-Mueller counter and scalar for quantitative measurements Determination of Al absorption curve for Bi^{210} Preparation of sources for counting Effects of material of source mount on counting	1 μc. Pb^{210} (specific activity 200 mg./μc.) in equilibrium with Bi^{210}	G-M counter, standard shelf arrangement, amplifier-scalar (×64 or larger), lead shield
3	Activities in Equilibrium with Uranium and Their Use for Calibrating β-ray Counting Assemblies	Quantitative separation of Th^{234} from $UO_2(NO_3)_2$ solution Use of Th^{234}-Pa^{234} source for calibrating counting assembly Solvent extraction separation of Pa^{234} from UO_2Cl_2 solutions Determination of long half-life (Th^{234}) by decay, and short half-life (Pa^{234}) by growth and by decay	3 g. of U in a standardized solution of $UO_2(NO_3)_2$ 8 g. of U as HCl solution of UO_2Cl_2 in sealed plastic tube with hexone.	G-M counter equipment
4	Use of the Lauritsen Electroscope and Comparison with the G-M counter	Determination of the linearity and sensitivity of the electroscope Comparison of sensitivity with that of the G-M counter	5 μc. Ce^{144} in equilibrium with Pr^{144}	Lauritsen electroscopes, G-M counter equipment
5	Study of the Ce^{144}-Pr^{144} Chain	Separation of these two nuclides by precipitation of $Ce(IO_3)_4$ Measurement of the half-life of Pr^{144} by growth and decay curves Analysis of a complex Al-absorption curve for β-ray energy determinations	Same as for Experiment 4	G-M counter equipment
6	Iodine and Barium Fission Products	Isolation of radioiodine from fission product mixtures Analysis of complex decay curve to determine half-life of I^{134} Separation and decontamination of Ba^{140} from fission product mixture Determination of fission rate from I^{134} and Ba^{140} activities	10 g. of U as $UO_2(NO_3)_2$ irradiated in neutron flux ~10^8 for 1–2 hr. or 500 g. of U as $UO_2(NO_3)_2 \cdot 6H_2O$ irradiated with 1 g. Ra-Be neutron source for 4 hr.	G-M counter equipment
7	Neutron Activations	Analysis of complex β-ray decay curve of Ag^{108}-Ag^{110} Determination of the relative neutron-capture cross section of Ag^{107} and Ag^{109} Concentration of a radionuclide by the Szilard-Chalmers reaction Measurement of the efficiency of this process for Mn^{56} from $KMnO_4$	0.1 g, Ra-Be neutron source, 1 g. Ra-Be neutron source, or the cyclotron	G-M counter equipment
8	Coseparation with Hydrous Precipitates	Measurement of the amount of Ba^{140} carried on LaF_3 precipitates as a function of Ba^{++} present, temperature of precipitation, and age of precipitate	1 μc. Ba^{140} in equilibrium with La^{140}	G-M counter equipment

TABLE 2 (Continued)

No.	Title	Objectives	Radioactive material for 12 students	Special equipment
9	The Analysis of γ-ray Absorption Data	Determination of γ-ray energies by Pb absorption curves Construction of β-ray absorption curve (Al) for β to γ counting ratio Determination of the effects of geometry on γ-ray counting and absorption	20 μc. Co^{60} 20 μc. I^{131} 20 μc. Ba^{140}	G-M counter equipment
10	Chemical Separations by Ion Exchange	Use of cation exchange resin for the separation of carrier-free La^{140} from Ba^{140} Measurement of the effect of pH and complexing agents on the affinity of ions for the resin	60 μc. Ba^{140}-La^{140} mixture (carrier free)	G-M counter equipment, G-M survey counter, solution counter
11	Some Problems in Measuring Low Energy Radiation	Determination of the effect of self-absorption in the counting of samples of C^{14} Comparison of the counting efficiency of standard G-M counter with windowless G-M counter	5 μc. C^{14} as Na_2CO_3	G-M counter equipment, windowless counter
12	Cyclotron Target Separations	Electrochemical separation of carrier-free Cu from bombarded Ni Solvent-extraction separation of Co from Ni Determination of the thick-target yields for several deuteron reactions	10-minute deuteron bombardment with cyclotron	G-M counter equipment

search groups. The cyclotron provides the best neutron source available here and has been frequently used. Its higher neutron flux ($\sim 10^8 n/cm.^2/sec$) simplifies several experiments, but it is essential only for No. 12.

The laboratory space for the course is a standard laboratory bay designed originally for organic classes and it is used without modification. Standard laboratory equipment is used for all of the experiments.

One teaching fellow and a part-time laboratory technician assist in the laboratory. The teaching fellow supervises the preparation for the experiments and assists in conduct of the laboratory. He also subdivides the radioactive stock solutions to levels below the hazardous. The technician prepares reagents and services the electronic equipment, making minor repairs and adjustments. Major repairs are made in the electronics shop.

The class is divided into two laboratory sections of six each, so that each student has his own counting equipment. Most experiments are conducted individually but occasionally the students work in pairs. Experiments 8 and 9 are divided so that each student does part of the experiment and then combines his results with others in his section to prepare a complete laboratory report of the experiment.

The key to the low expense[8] of this laboratory course is the availability of counters and health-physics equipment from research channels for the small fraction of the working time that they are used for education. The accumulation of long-lived radioactive sources over the years cuts operating costs for radioactivity to a low level. It is possible that the Isotope Division of the Atomic Energy Commission can be persuaded to prepare an educators' packet of several radionuclides and a 60*d* Sb^{124}–beryllium-metal neutron source if many schools indicate their interest.

The authors have learned a great deal in the working up of the material for this course and still notice considerable growth each year in the lecture work and in the handling of the laboratory. The students find that radiochemistry is not simple and that its results are not very precise unless they give great attention to technique. The experiments are not outlined in great detail for them, or the manner of expected write-up specified minutely, because it is deemed important to develop a sense of initiative. Although the experimental work is limited to β and γ counting, they have been exposed to all principles of radiochemistry except micro-manipulations for the highly specialized field of α emitters, almost all of which are hedged by secrecy restrictions. It is felt that this course has found a permanent place in the program of teaching and research at M. I. T., and that it has found a fairly stable form.

[8]The materials listed in Table 2 that are purchased from the Isotopes Division of the AEC are: 5700*y* C^{14}, 5.3*y* Co^{60}, 25*y*, Sr^{90}, and 275*d* Ce^{144}. The short-lived species 8.0*d* I^{131} can usually be borrowed and returned. The 12.8*d* Ba^{140} must be ordered each semester. The 22*y* Pb^{210} in lead foil used for Experiment 2 was prepared by diluting Pb^{210} from old radon seeds with ordinary lead.

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NOMINATIONS FOR THE JAMES FLACK NORRIS AWARD FOR OUTSTANDING ACHIEVEMENT IN THE TEACHING OF CHEMISTRY

The Board of Directors of the Northeastern Section of the American Chemical Society have voted to call for nominations so that the first grant of the James Flack Norris Award may be made at the meeting of the Section on May 10, 1951. Nominations, accompanied by ample supporting evidence of the achievements of the nominee, should be sent to any one of the members of the following Canvassing Committee:

Ernest C. Crocker, Chairman, Arthur D. Little Company, Cambridge, Massachusetts.
Hubert N. Alyea, Princeton University, Princeton, New Jersey.
Samuel T. Arnold, Brown University, Providence, Rhode Island.
Paul D. Bartlett, Howard University, Cambridge, Massachusetts.
James A. Campbell, Oberlin College, Oberlin, Ohio.
Helen W. Crawley, Walnut Hill School, Natick, Massachusetts.
Edwin R. Gilliland, Massachusetts Institute of Technology, Cambridge, Massachusetts.
Harold A. Iddles, University of New Hampshire, Durham, New Hampshire.
John A. Timm, Simmons College, Boston, Massachusetts.

The nominations, which should be submitted immediately, will be transmitted by the Canvassing Committee to the Award Committee. The personnel of the latter committee is kept secret.

The James Flack Norris Award shall be made for outstanding achievement in the teaching of chemistry, particularly when demonstrated at college and secondary school levels rather than shown in the direction of research. The award is given in memory of the late James F. Norris in accordance with the wishes of the late Mrs. Anne C. Norris who left a substantial bequest to the Northeastern Section to be used to perpetuate the memory of her husband.

Professor Norris was a student of Ira Remson, one of chemistry's greatest teachers. He gained his outstanding reputation as a chemistry teacher at Harvard and Clarke Universities, as Professor at Vanderbilt University and Simmons College, and at the Massachusetts Institute of Technology where he became Director of the Research Laboratory of Organic Chemistry. He was chairman of the Northeastern Section, was twice President of the American Chemical Society, and served on its Board of Directors for eleven years. He was also interested in the applications of chemistry to industry and served frequently as an industrial consultant.

The award comprises both a sum of money and a scroll suitably engrossed with an appropriate citation. It is the intention of the Northeastern Section to give this award biennially in years alternate with the Richards Medal for achievement in research.

ROTATIONAL TRAINING ASSIGNMENTS IN THE ATOMIC ENERGY INDUSTRY

R. E. CURTIS
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A TRAINING program for four-year level graduates in scientific and engineering courses was initiated in January, 1950, at the Hanford Works, the 400,000-acre plutonium production plant in southeastern Washington which is operated by the General Electric Company as prime contractor for the U. S. Atomic Energy Commission. This is an on-the-job training program in which graduates in chemistry, physics, metallurgy, chemical engineering, mechanical engineering, electrical engineering, and industrial engineering are assigned to work in the several plants and laboratories in a series of three-month successive assignments before definite placement in a particular type of work. In addition to a major program of production of plutonium, there are major requirements for applied research or development, design and service activities to support this production requiring a large number of technical trained personnel. Thus, the activities for technical men range from applied research through the advanced development of new ideas, processes and materials, to specific design of new equipment, plants and facilities, as well as the operation of the plutonium-producing plants. Consequently, all types of skills, aptitudes, and interests are required in the various scientific and administrative activities. Rotational training to assist young engineers and scientists to acquaint themselves with the many types of work in the plants and laboratories is thought to be new to atomic energy installations. However, this type of training for new graduates has been used by General Electric for sixty years in its commercial installations.

The objectives of the Rotational Assignment Training Program are as follows:

1. To explore and develop the interests of the young graduate fresh from the college and university atmosphere and to assist the graduate in the transition to the industrial environment.
2. To establish a firm basis for permanent placement of the graduates in the operating, design, and development divisions at the Hanford Works.
3. To fill positions with men who are both qualified and interested in a particular assignment.
4. To show the graduates how the basic concepts learned in college are applied in this industry.
5. To provide the incentive and means for advancement.
6. To maintain a more effective work program and more satisfied employees.
7. To give the new graduate a better comprehension and understanding of the entire operation.
8. To provide a department-wide pool of manpower to fulfill new or sudden requirements.

Graduates selected to receive this specialized training are carefully chosen from the universities and colleges. Generally, in this selection inherent traits such as integrity, initiative, industry, persistence, fairness and skill in human relations, and the ability to work effectively with others are required. In this selection, scholastic attainment generally serves as some guide to the ability of the student to grasp and analyze problems.

Upon reporting for assignment on the program at Hanford Works, the new graduate is carefully interviewed to determine his interest, and his first assignment of three months is usually made on a basis of the graduate's expressed preference for a type of work, *i. e.*, development, design, production, or service activities. After a period of 2 to $2^1/_2$ months on an assignment the graduate is again formally interviewed to determine whether his initially expressed interest is still dominant or whether new interests have developed. The placement in the second assignment is then based upon these developing interests. This interview procedure is then repeated at the end of the second three-month assignment and again during the third three-month assignment; thus, the graduate has had a chance to fully express his interests as they may have developed. Useful work is performed by the trainees during each three-month assignment, during which an adequate comprehension of the work, responsibilities, and the functions of a particular division is attained. His work performance on each of these assignments is rated by supervisory or other personnel in responsible postions who know the quality of the graduate's work performance. Traits or characteristics which are rated are as follows: industry, judgment, analytical ability, dependability, initiative, creative ability, perseverance, business consciousness, leadership, personality, and loyalty. These ratings are discussed with the graduate in a friendly progressive manner so that he may be aware of the traits which should be helpful in his advance as well as those which he should endeavor to improve.

Informal contacts are made with the graduates on the job by the training-program supervision in addition to the formal contacts previously mentioned. Also, contacts are made with supervision to assure that the assignment responsibilities are maintained at a level to fully utilize the graduate's capacity to do useful work. An effort is made to answer all the graduate's questions as completely as possible at all times and every effort

is made to make him feel that he fully belongs to the division to which he is assigned.

At the conclusion of the several assignments, every effort is made to place the graduate in the type of work for which he expresses his strongest preference. Generally, this work preference directly correlates with the work performance ratings.

Careful long-range forecasting of the manpower needs of the operating, service, design, and development divisions is required, so that the needs of these divisions may be adequately filled at the conclusion of an individual's training period and to insure each man an opportunity. To assist the divisions in selecting graduates from the training program, complete personnel records, including personal data, education, work performance ratings, interest preference, and records of interviews are maintained.

In summary, this program is designed to further develop graduates whose abilities, interests, and effectiveness will form a strong nucleus in the future organization. Perhaps the most important result is that each new graduate can feel that his own choice and performance largely determine what his first responsible post-training position will be.

STUDENT EXPERIMENTS ON ION EXCHANGE[1]

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Since ion exchange has reached importance as a tool of both fundamental and industrial chemistry, it is desirable that some time be devoted to this subject in undergraduate courses. To this end, an important part of the course in advanced inorganic chemistry in this department has been devoted to the fundamentals and applications of ion exchange. The experiments described in this paper have been used in the laboratory to illustrate typical applications of ion exchange columns. Experiments on the fundamental properties of an ion exchange resin have been described by Connick and Powell.[2]

The experiments presented here demonstrate the softening of water, the recovery of a metal from dilute solution, and the separation of similar metal cations. The columns used are easily prepared from laboratory burets.

The experiment on water softening, besides demonstrating the difference between untreated tap water and water which has passed through the column, illustrates the exhaustion and regeneration of a column. The recovery experiment removes lanthanum ion from a very dilute lanthanum nitrate solution and elutes it with hydrochloric acid, demonstrating in addition the conversion of a nitrate to a chloride. Almost any cation exchange resin is suitable for these experiments; Amberlite IR-100, Nalcite HCR, Amberlite IR-120, and Zeo-karb-H have been used. Amberlite IRC-50 is especially suitable for the lanthanum experiment, since very little acid is needed for the elution.

Cadmium and copper were chosen as cations to illustrate the techniques which have been applied to separations of rare earths and other sets of similar metal cations.[3] Both cations are readily obtained and easily distinguished from each other by the simple tests used in elementary qualitative analysis, yet the solubility and complex-ion forming properties of the two ions are qualitatively quite similar. Like different rare earth cations, these two cations differ sufficiently in their tendency to form citrate complexes that they may be selectively eluted by citrate solutions from a cation exchange column.

To obtain a good copper-cadmium separation in a small column requires a high-capacity strong acid type resin such as Amberlite IR-120 or Nalcite HCR (Dowex-50). While both these resins have been used successfully in these experiments, the experimental details given are those worked out with the latter. The column must be in the salt form (sodium or ammonium) rather than in the acid form—else the acid of the column destroys the citrate eluant.

Preparation of the Column. Above the stopcock in a 50-ml. buret place a wad of glass wool just large enough and packed enough to prevent resin particles from entering the stopcock. Stir up the resin to be used with distilled water and pour the suspension into the buret. Leave the stopcock open so the excess water can run out. The resin will settle to the bottom of the buret. Continue pouring resin suspension into the buret as the water runs out, until there is enough resin to fill the buret to about 5 inches from the top. During this pro-

[1] Presented in part at the Southeastern American Chemical Society Regional Meeting, Oak Ridge, Tennessee, June 11, 1949.

[2] Connick, R. E., and R. E., Powell, "Chemistry 120 Syllabus," University of California, Berkeley, 1948, p. 37.

[3] See, for example, E. R. Tompkins, *J. Am. Chem. Soc.*, 70, 3520 (1948); B. H. Ketelle and G. E. Boyd, *Ibid.*, 69, 2800 (1947).

cedure and all subsequent work with the column the water level must not be allowed to drop below the top of the resin bed, since removing air from the resin bed is very difficult. While the resins are resistant to dilute acids, it is best that the column never be left filled with acid.

SOFTENING OF WATER

Hardness in water is caused by the presence of calcium and magnesium ions (in Louisville, largely calcium). It can be removed by passing the water through a column of the sodium form of almost any cation exchanger (not the hydrogen form, since hydrogen ion interferes with the soap test), sodium from the resin replacing the calcium or magnesium in solution. Water hardness can be demonstrated qualitatively by the precipitation test with oxalate, semiquantitatively by test with a standard soap solution.

Soap Test for Hardness. Titrate 50 ml. of water with standard soap solution until as good a lather is obtained as with 1.00 ml. of soap solution and 50 ml. of distilled water. The harder the water the greater the volume required; soft water requires 1.00 ml. The standard soap solution is prepared by suspending 20 gm. of pure soap in water, adding 500 ml. of alcohol (ethyl or isopropyl), and diluting to one liter.

Procedure. Prepare a column of the sodium form of the resin to be used. Run tap water through the column discarding the first 20 ml. of effluent which was probably held up in the column at the start. Then collect two 50-ml. samples of the effluent. Test one for Ca^{++} with 2 ml. of saturated ammonium oxalate; test the other for hardness using the soap test. At the same time test similar samples of untreated tap water.

If an indefinitely large volume of water is treated by the same column, eventually such a large proportion of the cations on the resin will be Ca^{++} and Mg^{++} that the resin no longer is effective for removing these ions from the water. To illustrate the depletion of the column pour through the column a solution containing 3 grams of $CaCl_2$ and follow with sufficient water to wash off any Ca^{++} not picked up by the resin. Then collect two 50-ml. samples of column-treated water and test for hardness and Ca^{++}, comparing results with the previous results.

The column can be regenerated by removing the Ca^{++} with concentrated NaCl solution, reversing the equilibrium:

$$Ca^{++} + 2NaR \rightleftarrows 2Na^{+} + CaR_2$$

(R = one equivalent of resin anion)

To regenerate the column, pass 200 ml. of saturated NaCl solution through the column. Test a portion of the effluent for Ca^{++}. After the column is treated with NaCl solution and washed, again test samples of column-treated tap water for hardness and Ca^{++}.

RECOVERY OF A RARE ELEMENT

Use a column which is completely in the hydrogen form. Pass through the column 200 ml. of lanthanum nitrate solution (100 mg./l). Test the effluent with litmus paper and interpret the result. Wash the column with 50 ml. of water and then with 100 ml. of hydrochloric acid. Collect the effluent from the latter and evaporate to dryness. The white solid is lanthanum chloride. If the residue is too bulky for the quantity of lanthanum expected, it is probably sodium chloride present because the resin was not completely in the acid form at the start of the experiment.

SEPARATION OF SIMILAR METAL CATIONS

This experiment is based on the fact that citrate complexes of Cu^{++} and Cd^{++} are not equally stable, so that one of these cations is removed from the column more rapidly than the other by citrate solutions. Concentrations of diammonium citrate greater than that recommended will complex both ions to the extent that they will be eluted together and not separated. The second ion should be eluted with ammonium chloride rather than hydrochloric acid if the column is to be used again for this experiment, even though the acid is the more effective eluting agent.

Test for Copper. To a few milliliters of the effluent add a few drops of 0.5 *M* potassium ferrocyanide. A wine-red precipitate indicates the presence of copper.

Test for Cadmium. Make 1 ml. of the effluent alkaline with ammonia and dilute to 10 ml. If copper is present add 0.5 *M* potassium cyanide until the solution is colorless. Saturate with hydrogen sulfide. A yellow precipitate indicates the presence of Cadmium.

Procedure. Use a column which is filled with Nalcite HCR (Dowex 50) in the sodium or ammonium form. If the resin has not previously been used, it is probably in the sodium form. If it is in the hydrogen form it may be converted to the ammonium form by passing 200 ml. of saturated ammonium chloride through the column.

Pass 50 ml. of 0.20 *M* diammonium citrate through the column to "pretreat" the column, that is, to make the H^{+}-NH_4^{+} balance in the column the same as during the separation. Add to the column 10 ml. of a solution 0.05 *M* in cadmium nitrate and 0.05 *M* in copper nitrate. Follow this with 0.20 *M* diammonium citrate, collecting 50-ml. samples of effluent. Test each effluent sample for Cu^{++} and Cd^{++}. When the ion eluted no longer appears in the effluent (probably after four samples) substitute either 3 *M* hydrochloric acid or saturated ammonium chloride for the citrate solution and continue taking 50-ml. samples and testing for the ions until the second ion has been removed from the column.

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ARTHUR STOLL

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ARTHUR STOLL, internationally known organic chemist, was born at Schinznach (Aargau) Switzerland on January 8, 1887. He entered the Eidgenossische Technische Hochschule at Zurich in 1906. Even before his training was complete, Willstätter accepted young Stoll into his research laboratory and entrusted him with investigations on chlorophyll, particularly the enzymatic cleavage with chlorophyllase. Further studies dealt with the nature of the cleavage products, the chlorophyllides, and their separation into components *a* and *b*. The diploma of the E.T.H. was conferred in 1910, and the doctorate in 1911. The next year, Dr. Stoll accompanied Prof. Willstätter to the newly erected Kaiser Wilhelm Institut in Berlin-Dahlem, and again in 1916 to the University of Munich, where Willstätter was succeeding Adolf von Baeyer. During the first world war Stoll continued his work on chlorophyll and later he took up its function in green leaves and its part in photosynthesis. Two books were published jointly with Willstätter, namely "Untersuchungen über Chlorophyll" (1913) and "Untersuchungen über die Assimilation der Kohlensaure" (1918).

During his Munich period, Stoll also studied peroxidase, and these researches formed the beginning of Willstätter's extensive investigations on enzymes. Stoll's long association with Willstätter had ripened into close friendship, and it was most fitting that he should be entrusted with the publication (1949) of Willstätter's "Aus meinem Leben."

In 1917 Dr. Stoll accepted an offer to go into industry, to found and direct a new pharmaceutical department in Sandoz, Inc., the well-known Basle firm. Here for the past thirty years he has been busy with the basic idea of using the methods worked out in connection with chlorophyll and enzymes for the study of other sensitive natural substances which might be of medical value.

As early as 1918, he had isolated the pure alkaloid ergotamine, and thus opened a new and interesting chapter in ergot chemistry. Six pairs of ergot alkaloids have now been isolated: ergotamine–ergotaminine; ergosine–ergosinine; ergocristine–ergocristinine; ergokryptine–ergokryptinine; ergocornine–ergocorninine; ergometrine–ergometrinine (ergobasine–ergobasinine). Only the second pair was discovered outside of the Sandoz laboratory; the last pair was isolated simultaneously by Dudley (England), Kharasch (Chicago), Thomson (Baltimore), Stoll (Basle).

The laboratories directed by Stoll have contributed greatly, especially during the past 10 years, to the knowledge of the constitution of the ergot alkaloids, which have been shown to be polypeptides. Among the derivatives of the natural ergot alkaloids, the less toxic dihydro alkaloids offer great promise; they exert powerful action on the autonomic nervous system. The field of application of ergot derivatives, originally limited to obstetrics and gynecology, has now been extended to internal medicine, neurology, psychiatry, and still other branches of medicine. This expansion has been made possible through fundamental studies of the chemistry of these highly active materials, and especially by the isolation of the pure alkaloids, and the preparation of derivatives, either by hydrogenation or partial synthesis. Examples of the latter are methyl ergobasine and lysergic acid dimethylamide.

The Sandoz laboratories for the past 30 years have been actively interested also in the cardioactive glycosides. The first success in this field was the isolation from squill bulbs, of the glycosides scillaren A and scilliroside; the latter is also a potent rat poison. The recognition by Stoll that most of the cardiac glycosides known prior to 1930 are products of the enzymatic degradation of natural glycosides having a higher sugar content, led to the discovery of a series of "genuine" glycosides, *i. e.*, the glycosides as originally present in the plant. They were obtained from *Digitalis lanata* (lanatosides A, B, and C), *Digitalis purpurea* (purpurea glycosides A and B), the seeds of *Strophanthus kombé* (k-strophanthoside), etc. The Sandoz laboratory has played an active part in elucidating the constitution of the cardiac glycosides. As a result of these studies by Stoll and his associates a whole series of genuine glycosides has now been introduced into therapy.

Interesting new discoveries have come also from his studies of alliin, the specific principle of garlic oil, and the isolation of sennosides A and B, the chief active principles of senna leaves. The structures of alliin and of the latter glycosides have been successfully determined.

In the early 1930's Dr. Stoll turned once again to chlorophyll chemistry. He made valuable contributions to the fine structure of the chlorophyll molecule. Later, his interest centered on the state of the chlorophyll in the chloroplasts and, with the aid of his associates, showed that it is present as a chromoprotein, a complex similar to that of the blood pigment in hemoglobin. In chloroplastin, a name coined by Stoll, the linkage between the pigment and the protein is much looser than in hemoglobin. The extreme lability of chloroplastin and the size of its particles make these studies, which are still under way, extremely difficult.

Dr. Stoll's work has been given widespread recognition. Besides ten honorary doctorates (medicine, pharmacy, technical sciences, etc.) conferred by schools

in various countries, and honorary membership in learned societies, he holds such important awards as the Marcel Benoist Prize (Switzerland, 1943); Flückiger Gold Medal of the Swiss Pharmaceutical Society (1943); Chevreul Medal of the Society of Chemical Industry (France, 1946); Pasteur Medal of the French Biochemical Society (1948). He is now (1950) President of the Conseil de la Chimie Suisse, and has been nominated Extraordinary Professor at the University of Mexico.

SCIENCE EXHIBITS

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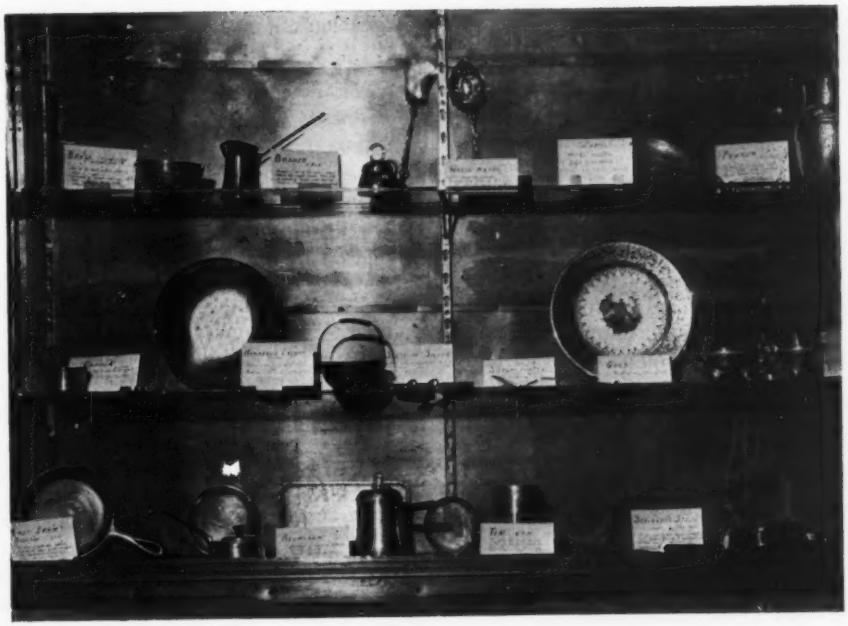
SCIENCE teachers who are charged with the responsibility of preparing and arranging periodic exhibits in the hall wall cases of their schools know what a difficult and time-consuming job it is. It requires alertness, preparation, skill, thoughtful arrangement, and instructive labeling, and a constant search for ideas for interesting and provocative displays. A science exhibit must achieve several worthwhile aims. In the first place it should be interesting, attractive, and entertaining. Secondly, the exhibit should be instructive to those who stop to look and to learn. It should arouse a desire to find out more about the principles, processes, facts, materials, or ideas presented. Third, a good exhibit should serve as an advertising medium not only for the science course from which it was drawn but for all science courses offered in the school curriculum. It can and will *sell* science to the general, commercial, and college-preparatory students.



Alloy Exhibit[1]

An attractive display, entitled "Metals and Metal Alloys Used in the Home," was the center of attraction for several weeks. On display were copper utensils, chrome-plated sugar bowl and creamer, stainless-steel kitchen utensils and tableware, sterling silver and silver-plated tableware, aluminum pots and pans, pewter pitcher and serving dish, a bronze bell, brass candlesticks and coffee pot, tin cans, hammered copper and oxidized silver bowls, and other objects found in the home. Each item was identified by a card with a brief description of the composition of the alloy, the properties which make it particularly useful, and other interesting information about the metal or alloy. It is planned to follow this exhibit with similar ones on functional plastics, glassware, and ceramics.

[1] Prepared in cooperation with Mrs. Margaret C. Teal of the C.H.S. Chemistry Department.

A COURSE ON THE DETERMINATION OF ORGANIC COMPOUNDS

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RECENTLY two symposia (*1*, *2*) have been given in which the need for instruction in organic analytical chemistry was stressed. It is also evident from the ease with which students trained in quantitative organic analysis may be placed. Modern organic research also demands a knowledge of the subject and preferably practical experience in its application. A discussion of the program at Michigan State College is offered to help other institutions which may be thinking of such a program avoid the difficulties which of necessity plague a course in a new subject.

The term "quantitative organic analysis" includes at least three different approaches to the estimation of organic substances as follows:

1. Elemental analysis
2. Determination of functional groups
3. Determination of compounds

Elemental analysis is a good descriptive term for analyses based on the determination of carbon, hydrogen, oxygen, halogen, sulfur, etc., whether it be on a micro, semimicro, or macro scale. The determination of functional groups suggests an estimation of amino, carboxyl, hydroxyl, carbonyl, etc., groups regardless of the compounds present. The determination of organic compounds, on the other hand, will include the functional group determination and in addition will attempt to describe the sample in terms of compounds. The determination of compounds will therefore be based not only on the functional group but also on the remainder of the molecule. As a result, training in the determination of compounds will serve as an integrating process for analytical and organic chemistry and not merely as a memory course in procedures.

The teaching of organic analysis may be done with several objectives in mind. The more reasonable ones may be summarized as follows:

1. The correlation of organic theory and analytical practice.
2. The integration of reactions of organic compounds on an analytical basis.
3. Extension of the scope of organic chemistry by the instruction of less familiar reactions.
4. Extension of the scope of analytical chemistry.

It is unreasonable to consider the increase in laboratory experience as one of the main objectives because relatively little new laboratory manipulation can be introduced. In general, objectives 1 and 2 have received the most emphasis of the program because the student usually needs to apply analytical thinking to the organic problem. This point of view is in agreement with the philosophy that chemical education should train chemists and not technicians. These two objectives will also force the student into a development pattern which will not be completed when the program ends but will provide the factual basis and the thought pattern for the solution of other problems as they occur.

THE PROGRAM

The proper development of organic quantitative analysis requires a certain amount of background material. Organic chemistry, through qualitative analysis, and analytical chemistry including volumetric, gravimetric, and some instrumental methods—*e. g.*, potentiometric and colorimetric techniques—are essential. In addition some physical chemistry is desirable but is not an absolute necessity. In general, to satisfy these prerequisites the program must appear at the end of the senior year or in the first year of graduate study. We have found that the latter time is preferable, apparently because the graduate student appreciates the integration approach and perhaps has already started himself, whereas the average senior is not ready or is unwilling to make the effort. In any case, the alternative selected will depend on the remainder of the chemistry curriculum available.

The selection of the material to be covered both in the lecture and the laboratory is critical and must be done with care. In the first place, the quantity must not be too great. Consideration of hydrocarbons, alcohols, carbonyl compounds, acids and acid derivatives, amines, nitro compounds, sulfur compounds, and a few selected miscellaneous compounds, both as classes of compounds and with regard to individual compounds, provides more than enough for 22- to 26-hour discussions depending on the detail introduced. Secondly, the nature of the material considered must be scrutinized to avoid a monotonous discussion which could be read with greater value. For example, an hour can be spent profitably on the theory of nonaqueous solvents for acidimetry, but time would be wasted if the hour were spent on the many adaptions proposed for the determination of saponification number. In the third place, the methods discussed should be as general as possible. Determinations of limited scope are desirable when considering individual compounds but should not constitute the major part of the work. The work in the

TABLE 1
Laboratory Experiments in First Quarter

Determined	*Group I. 2 to be done* *Diluent*	*Reference*
Cyclohexene	Benzene	4
Salicylic acid	Benzoic acid	5
Amyl acetate	Acetic acid	
Ethylene glycol	Water	6
Glycerol	Water	7
n-Butylamine	Carbitol–water	8
Determined	*Group II. 1 to be done* *Precipitant*	*Reference*
Formaldehyde	Dimedone	9
Methyl ethyl ketone	3,5-Dinitrophenylhydrazine in 4 *N* $HClO_4$	10
Pyridine	Cupric thiocyanate	11
Mixture	*Group III. 2 to be done* *Method*	*Reference*
Formic acid–water	Alkaline permanganate	12
Dinitrobenzene–benzoic acid	Reduction	13
Acetic, propionic acids–water	Distribution	14
Phthalic acid–Phthalic anhydride	Acidimetry	15
Salicylic acid–benzoic acid	Bromination and acidimetry	5
Determined	*Group IV. Required* *Method*	*Reference*
Water	Karl Fischer	16

laboratory may be varied to fit the need, but it is most satisfactory if the methods are general in nature. The work is usually new to the student, although the fundamental manipulations are familiar. It is clear from experience that the determinations used must be neither too easy nor too difficult. For example, the determination of an acid by titration with sodium hydroxide does not challenge the student. On the other hand, the use of a phenol and nonaqueous medium requiring a potentiometric end point provides an interesting problem. However, if the determination requires complete absence of water, oxygen, and carbon dioxide, the student feels he faces a monumental problem, and the work he does will reflect discouragement. It is also important not to load the laboratory program for the same reason.

A program in quantitative organic analysis would logically include some material on process control, whether the process be on a laboratory scale or on a production scale. The requirements for the process studied should include the presence of by-products and a variety of different functional groups for consideration. Qualitative and quantitative aspects of impurities, intermediates, and products provide an excellent example of how analytical chemistry is applied either to a research problem or to production and, at the same time, stimulate the analytical thinking of the student.

In order to accomplish these objectives it was found necessary to extend the program over two quarters or 20 teaching weeks. For the first quarter, two lecture hours and three laboratory hours per week were scheduled and the general consideration of methods for classes of compounds and some individual compounds more than filled the class hours. The topics considered and the number of lecture hours were as follows: water (1), hydrocarbons (2), alcohols (2), carbonyls (3), acids and acid derivatives (4), phenols (1), nitro compounds (1), amines (2), sulfur compounds (1), heterocycles (1), examinations, quizzes, etc. (2). Six determinations were done, as shown in Table 1. For the second quarter, one lecture-discussion hour and six laboratory hours per week were scheduled. The synthesis of Orange I, starting from *p*-chloronitrobenzene and proceeding through *p*-nitrothiophenol, *p*-nitrobenzenesulfonic acid, sulfanilic acid, diazotized sulfanilic acid, and the coupling of this with α-naphthol. was used to illustrate the points previously mentioned. Eight determinations (Table 2) based on the synthesis or closely related compounds were assigned. All students were given the same sample so that the use of a control chart (*3*) could be discussed with meaning to the student rather than an abstract idea.

TEACHING DIFFICULTIES

From the point of view of the student it is desirable to have a textbook not only for reference but also as a guide to organization of the material. A textbook is also convenient, but not essential, for the instructor. The lack of a teaching textbook requires direct use of the original literature which is troublesome for the library and the students. Siggia (*25*) has made a helpful contribution of a suitable laboratory book, but a book with extensive discussion for class use is still unavailable. The problem of reference is, therefore, difficult, and it is hoped that a teaching textbook will be forthcoming.

How good a job may be expected from students doing a determination for the first time? In inorganic quantitative analysis accuracy and precision may be maintained at a high level, usually a few parts per thousand.

TABLE 2
Analytical Determinations for Study of Control

Substance	*Method*	*Reference*
p-Chlorophenol	Reduction and Ag^+ titration	17
Mercaptobenzthiazole	Ag^+ titration	18
Mercaptobenzthiazole	I_2 oxidation	19
Acetophenone	Volumetric oxime formation	20
p-Nitroaniline	Acetylation	21
Anthranilic acid	Diazotization	22
Resorcinol	Coupling	23
Azo compound	Reduction with Ti^{+3}	24

This is not hard to do because solubilities are low and only occasionally are unfavorable equilibrium constants encountered. In organic quantitative analysis, not only are incomplete reactions common, but volatility, side reactions, ease of oxidation, and the like are the rule. Papers in the literature cite data to show that a method is good to a few parts per thousand, but these data usually have been obtained by experienced operators (for an exception see reference *26*). It has been

found that the procedures from the literature yield results that are in error by 2 to 10 times the amount claimed by the authors. These results are not bad, if the inexperience of the student is considered. The difficulty, however, is that the instructor does not know what error is reasonable to expect, with the result that the first reports may be too severely criticized. One method for minimizing this difficulty is to use a control chart (*3*).

The third problem encountered in the teaching of organic quantitative analysis is the preparation of suitable unknowns. The problem is not as important in qualitative work since a pure substance is usually desired. For quantitative work, however, the situation is quite different. Not only is the initial purity of interest but the effect of the diluent may be more important. The substance to be determined may be analyzed before mixing, or the sample may be prepared and then analyzed. The latter is preferable because errors of mixing and other changes are actually corrected. The choice of the diluent is not so simple. The factors which must be considered include solubility, relative density for a solid, effect on storage (air and light as well as interaction), and availability. For solutions, a solvent with a low boiling point is not satisfactory, but, on the other hand, a solvent with high viscosity is just as bad. Water, methyl cellosolve, and isopropyl alcohol are useful, but others will be needed for solutions where these interfere. The most useful solid diluent is benzoic acid. It is readily available, mixes well by grinding, and is stable. The limited solubility in water must be remembered. Usual diluents such as sodium chloride and potassium chloride are unsatisfactory because the high density prevents good mixing when the organic part is more than a few per cent of the sample.

A fourth problem which may arise is the scale of the laboratory work. Many analytical chemists feel that all determinations should be done on a micro level. This may be the best for a trained chemist, but for the immature student the microtechniques are too difficult. Usually the range from 80 to 500 mg. is satisfactory for student work. After the student has become familiar with the methods, the application of microtechniques may be introduced with considerable benefit. In addition, there are very few schools which have sufficient micro equipment.

FUTURE DEVELOPMENT

At the present time the teaching of quantitative organic analysis is not popular. There is a demand for chemists with this training, and it is reasonable to expect the colleges and universities to provide the training. However, the undergraduate curriculum is so crowded now that it would seem best to have the training at the master's level in general. The question as to whether the course should be given by the analytical or the organic group must be decided. For the best results the analytical group should offer the course, because the emphasis should be placed on the analytical techniques. In any case, the development of a course will require ingenuity and patience until more of the teaching problems have been solved.

ACKNOWLEDGMENT

Acknowledgment is made to Frederick R. Duke who initiated the program and has provided encouragement for its continued development.

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MOLECULAR MODELS OF SILICATES FOR LECTURE DEMONSTRATION[1]

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THE silicates constitute one of the most complex groups of compounds commonly studied in freshman chemistry. In the past textbooks often presented the naturally occurring silicates with a formidable array of names and formulas such as: tremolite, $CaMg_2Si_4O_{11}$; muscovite, $KH_2Al_3Si_3O_{12}$; orthoclase, $KAlSi_3O_8$; and zeolite, $NaAlSi_2O_6$. Even the teacher probably did not remember these from one year to the next. It is not surprising that the average student found difficulty in remembering them long enough for the inevitable examination, to say nothing of any retention beyond the end of the course. Any attempt at having the students understand them was not even considered by the teacher. The structures of these compounds are well established (*1*), and in recent years some textbooks have improved the situation by including structural formulas, diagrams, and pictures of models. Molecular models of many of these compounds have been described (*2*, *3*, *4*), but due to lack of availability they are seldom, if ever, used in connection with elementary courses. The purpose of this paper is to show how the inexpensive type of molecular models commonly used for organic chemistry can be adapted to the silicates. (They were first used by the author in 1941 and have been found to be very helpful.) The material suggested here for a lecture on the silicates is hardly more than an outline, since it is impossible to include the detail that would be necessary in presenting the silicates to a class in chemistry.

In these models the various atoms are represented by the different colors as follows: silicon, black (8 dozen); aluminum, silver (1 dozen); hydrogen, white (2 dozen); chlorine, green (four); dicovalent oxygen, yellow (12 dozen); and monocovalent oxygen, red (7 dozen). (Approximately 24 dozen $1^1/_4$-inch pegs are used.) By using two colors for oxygen one can tell immediately whether a model represents a neutral molecule or an ion, and the charge on the ion is easily determined by merely counting the red "atoms." (At this point it is often advantageous to briefly review the theory of covalence and electrovalance for the students.) The black balls representing silicon and the silver balls representing aluminum each have four holes arranged in the same manner as for the tetrahedral carbon atom. The dicovalent oxygen "atoms" have two holes at an angle of approximately 140°. All others need only one hole each.

[1] Presented before the Division of Chemical Education at the Southwest Regional Meeting of the American Chemical Society, Oklahoma City, Oklahoma, December 10, 1949.

Following a rather common practice (*5*) the silicates are divided into four classes for purposes of this discussion: (1) the simple silicates, (2) the asbestos type (silicon-oxygen chains), (3) the mica type (silicon-oxygen sheets), and (4) the three-dimensional silicon-oxygen network. These will be considered in order.

Although not a silicate, the model of silicon tetrachloride is first shown to illustrate in the simplest manner the tetracovalent nature of the silicon atom. This is then followed by the model for the hypothetical orthosilicic acid and the orthosilicate ion (using red balls for the oxygen atoms in the latter). These are shown in Figure 1. The removal of a molecule of water from two

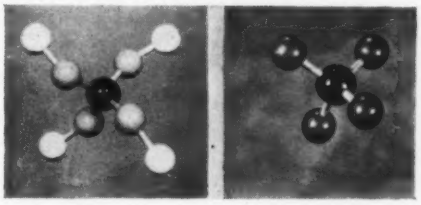


Figure 1

molecules of the ortho acid to form the hypothetical disilicic acid is easily shown. Figure 2 shows the model for this acid and the corresponding ion, $Si_2O_7^{-6}$, in which it can readily be seen that of the seven oxygen atoms, six are contributing to the charge, while one is dicovalent. Three molecules of orthosilicic acid may lose two molecules of water, forming the hypothetical trisilicic acid, $H_8Si_3O_{10}$. The teacher may show models of the cyclic, as well as the linear, trisilicate ion at this point. All of the compounds considered up to this point are classed as "simple silicates" (or as "self-contained groups" by Stillwell) (*5*) because in each case the crystal lattice is made up of discrete, individual ions surrounded by ions of the opposite charge. Such formulas as Na_4SiO_4, $Ca_2MgSi_2O_7$ may be shown to the students to illustrate common substances belonging to this class of silicates.

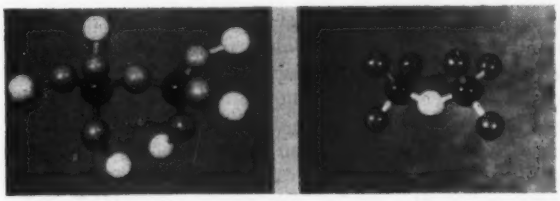
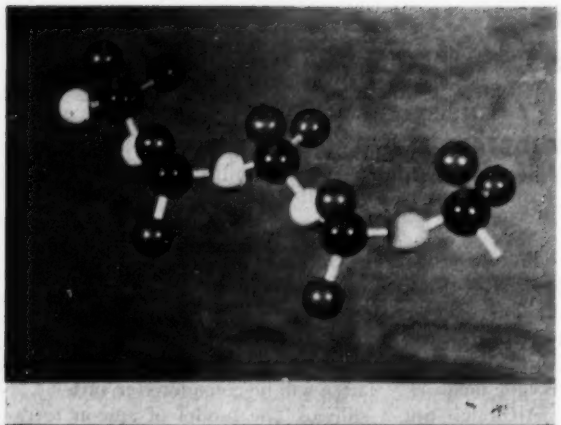


Figure 2



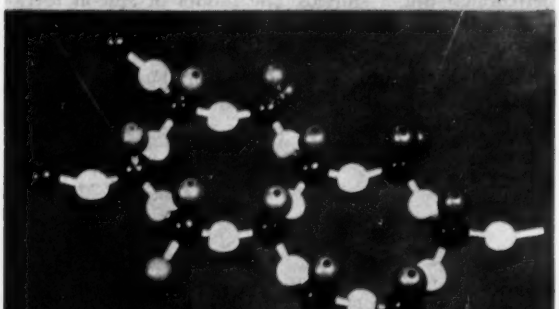
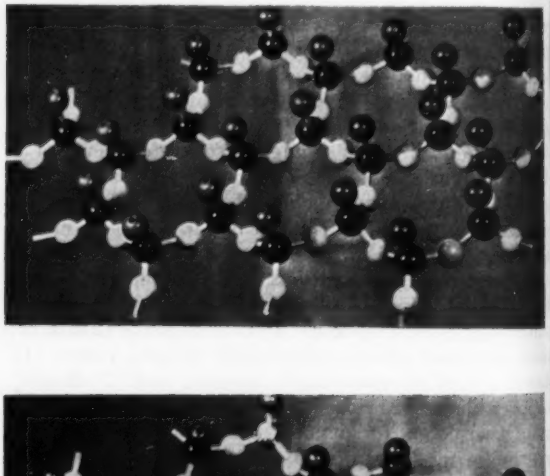


Figure 3 (*a*, above; *b*, below)

The structure of the asbestos type of silicate (Figure 3) follows easily from the linear trisilicates already mentioned. The pyroxenes are compounds in which there are single chains of alternating silicon and oxygen atoms to give continuous negative ions of indefinite length. The formula for diopside, $CaMg(SiO_3)_2$, shows that the empirical formula for the negative ion is that of the so-called metasilicates (Figure 3, *a*). Tremolite, $CaMg_2Si_4O_{11}$, illustrates another type of asbestos (the amphiboles). The model (Figure 3, *b*) shows quite clearly how a double silicon-oxygen chain can account for such an unusual formula. Of the eleven oxygen atoms indicated in the formula, five are dicovalent (yellow) while the other six are monocovalent (red), and each of the latter carries a negative charge. The $Si_4O_{11}^{-6}$ group may be located in the figure by counting these atoms from the right end of the model shown, or by considering any section of the double chain from one point to the next similar point where the repetition of structure begins. These negative charges are balanced by the positive charges of the metallic ions which lie between the silicon-oxygen chains. The fibrous nature of asbestos is thus explained on the basis of the relatively strong covalent bonds that exist within the long ions, as compared to the weaker electrostatic attraction that holds the bundles of ions together. A specimen of asbestos is shown at this point to illustrate the correlation between physical properties and molecular structure.

If we consider the single silicon-oxygen chain as a structure extending in only one dimension, then the double chain may be regarded as the beginning of an extension into a second dimension. It becomes apparent that a continuation of this process would result in a two-dimensional network. These silicon-oxygen sheets, extended indefinitely, constitute the negative ions that are typical of the micas. It is evident from the model (Figure 4, *a*) that the ratio of charge to total number of oxygen atoms has again decreased and the empirical formula for the ion is $Si_2O_5^{-2}$. Within these sheetlike ions the atoms are held together by covalent bonds, while the layers are held to each other by ionic forces, much like the chains in the asbestos type of compound. The discerning student soon notices that there are no $Si_2O_5^{-2}$ groups evident in the formulas commonly given for the various micas. This introduces a very important aspect of silicate structure which the models illustrate very well. The atoms of other elements may be substituted for the atoms of silicon in the silicon-oxygen networks. It is essential that the other atom be of approximately the same size as the silicon atom, but it need not have the same charge. Thus, aluminum (represented by the silver balls in the models) is very com-



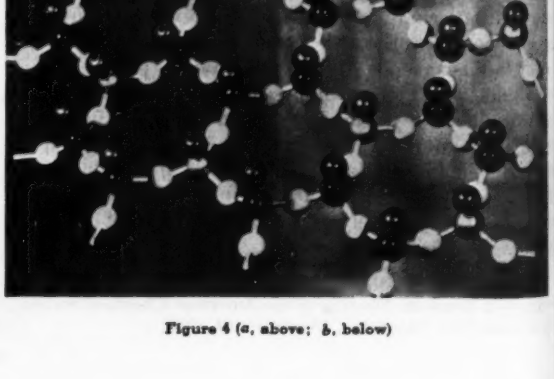


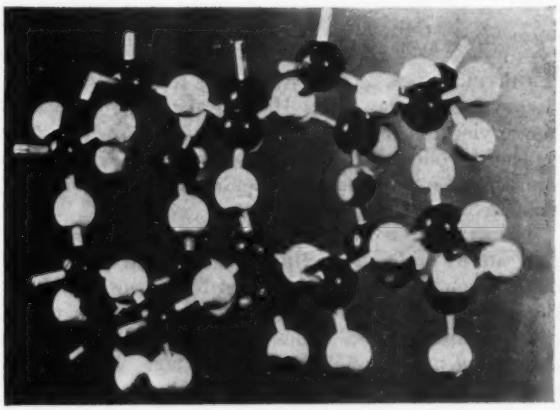
Figure 4 (*a*, above; *b*, below)

monly found in the silicates as part of the network. However, for each silicon atom replaced there must be an additional positive charge among the ions that are not in the network, due to the fact that aluminum has a charge of three instead of four. In this respect the formula for muscovite is more meaningful if written $KAl_2(OH)_2(AlSi_3O_{10})$ (*6*). This can be shown in the model by replacing one out of every four of the black balls by the silver ones (Figure 4, *b*). The other two aluminum ions along with the hydroxyl groups and the potassium ion comprise the layer of individual ions that lie between the silicon-oxygen sheets and are not included in the model. After illustrating these substitutions with the model, a sample of mica is presented to the students to show again the relation of molecular structure to physical properties.

If the monocovalent oxygen atoms (the red balls of the model) of the mica type are attached to the silicon atoms of another layer, we have the fourth type of silicate. Since these oxygen atoms are now dicovalent the red balls must be replaced by yellow ones. This is the three-dimensional network in which all charges have been eliminated so that it is a neutral molecule. It is evident in the model (Figure 5, *a*) that the ratio of oxygen to silicon has reached a minimum and we have the familiar formula for quartz, SiO_2. In showing the class a sample of quartz at this point its form is contrasted with the asbestos and mica already shown. This may be taken as a starting point for considering the more complex silicates like the kaolins, feldspars, zeolites, and others. For the model of the negative ion of orthoclase one out of every four of the silicon atoms (black) is substituted by an aluminum atom (silver) to give a network of the empirical formula $AlSi_3O_8^{-1}$ (Figure 5, *b*). The potassium ion is in the space enclosed by the network. These interstices within the model are pointed out to explain to the student why such ions are referred to as "interstitial" ions. The formula $Na_2H_4Al_2(SiO_4)_3$ (Natrolite) may be written $K_2(Al_2Si_3O_{10})2H_2O$ as another illustration of the place of the aluminum atoms in the structure (*7*).

A formula commonly given for a zeolite is $NaAlSi_2O_6$. In this case the interstitial ion is sodium and from a consideration of the model the student may see how such an ion in a zeolite water softener may be replaced without destroying the structure of the crystal. With this background, the equation for the exchange reaction of the water softener takes on more meaning for the student.

The models may be used in connection with a brief reference to the amorphous nature of glass. When a substance has a definite and regular structure then it usually exhibits a definite melting point, typical of the solid state. However, if the structure is irregular the amount of energy necessary to break down the structure in melting will not be uniform. The result is a softening process so obvious with glass. The models thus far have shown sheets and networks with rings containing six silicon and six oxygen atoms. It is a simple matter to illustrate the relatively haphazard nature of glass by opening several of these rings and changing them so that the network includes rings containing five, six, seven, and eight silicon atoms.



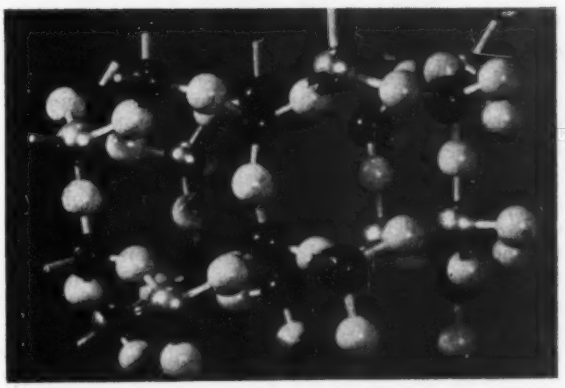


Figure 5 (*a*, above; *b*, below)

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PROMOTING RESEARCH IN THE SOUTHEAST

A Progress Report

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THIRTEEN years ago Dr. E. Emmet Reid, upon his retirement from the Johns Hopkins University, offered his services as a "travelling research consultant" to southern colleges and universities. This significant educational experiment has been described in some detail (*29, 31*).

Through the years Dr. Reid has continued to work the program as originally outlined. From the six original institutions the circuit has grown to eleven. Keeping the participating institutions down to a number which can be visited several times a session has been one of the vexing problems of the undertaking. During this past session Dr. Reid visited the following: Birmingham-Southern College, Emory University, Furman University, Georgia School of Technology, Howard College, Marshall College, Stetson University, University of Richmond, University of Alabama, University of South Carolina, and Washington and Lee University. For a professor emeritus to carry through such a schedule several times a year is a formidable assignment, but the manner in which Dr. Reid breezes through it amazes all connected with the program.

A research program lends itself to an objective evaluation by an examination of the number and quality of its published results. A total of fifty-four publications may not be impressive in some quarters, but few of the institutions visited had any productive research in progress when the plan was launched. A study of research produced by other institutions in the same region is relevant also: It is significant that one of the colleges on the circuit led all liberal arts institutions in the South in research published in *The Journal of the American Chemical Society* for the war years, 1942–45, and another is leading in postwar research (*50*). The reader may form his own opinion of the quality of the work done after examining the bibliography below. Only those articles are listed which acknowledge directly Dr. Reid's participation in the research.

Publications do not tell the whole story of such a venture. Scores of students who participated as undergraduates or Masters' candidates and who now occupy responsible positions in industrial and academic research have paid tribute to the man who conceived and labored through the years to make his dream a reality. Such tributes must gladden the heart of one who wrote in 1940: "A teacher without students is desolate."

Staff members of the institutions visited have been even more outspoken in appreciation of what Dr. Reid's contacts have meant to them personally and to their departments. But Dr. Reid has red-lined all references to those qualities of mind and heart which made the program so fruitful and inspiring.

After participating these years in such a venture one cannot but ask, "After Dr. Reid, what?" Dr. Charles A. Kraus, Priestley medalist for 1950, proposes some challenging suggestions for larger support of academic research (*Chem. Eng. News*, **28,** 3203 (1950)). It is also encouraging to note that a national foundation is currently spending well over a million dollars to test out a program which Dr. E. Emmet Reid has been working with marked success for thirteen years.

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A SIMPLE DEVICE FOR WEIGHING GASES

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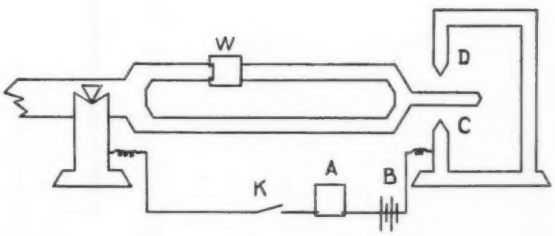
AT TIMES the chemist needs to know when a certain predetermined weight of gas has been used in an experiment. At other times he may wish to know the rate at which a gas has been delivered. The writers have devised a scheme for accomplishing the above purposes without encountering the difficulties involved in the use of the usual flowmeter. The device may resemble others in use, but no other system with an electric alarm attached has come to the attention of the authors.

Platform "scales" of the type usually found in feed stores were used. The capacity was 310 lb. The usual cylinder of gas was placed on the platform. An electric circuit with dry cells *B*, signal buzzer *A*, and knife switch *K* was attached to the system as shown in the accompanying diagram. With the knife switch closed and the beam in contact with the point *C* the circuit was closed through the beam and the buzzer would sound. With a total weight of 80 kg. on the platform this device could be adjusted so delicately that a variation of 5 g. would be enough to make or break the circuit. For this reason the cylinder was balanced roughly with the weight *W* on the beam and supplementary brass weights of the usual laboratory variety were placed beside the cylinder on the platform. The system



was considered to be balanced when the circuit was closed definitely enough to give regular clicks in the buzzer.

To use the device in weighing gas the system was first balanced as described above, and then a predetermined brass weight (say 100 g.) was added to the balanced platform. This lifted the beam and broke the circuit. After the corresponding amount of gas had been delivered, the circuit would automatically close and the buzzer would sound the alarm. To prevent the beam from making contact with the top of the "beam stop" *D*, that portion was insulated. Clean contacts were essential for accurate measurements.

Where a constant rate of flow was desired, a bubble counter was inserted in the line.

AMORPHOUS ANTIMONY

A Lecture Demonstration in Allotropy

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THE element antimony has four known allotropes:

1. Yellow Antimony. This is analogous to yellow arsenic and white phosphorus. It is transparent and soluble in CS_2. It is prepared by the action of oxygen on liquid stibine, SbH_3, at $-90°$. It is very unstable and changes even at low temperatures to the black allotrope.

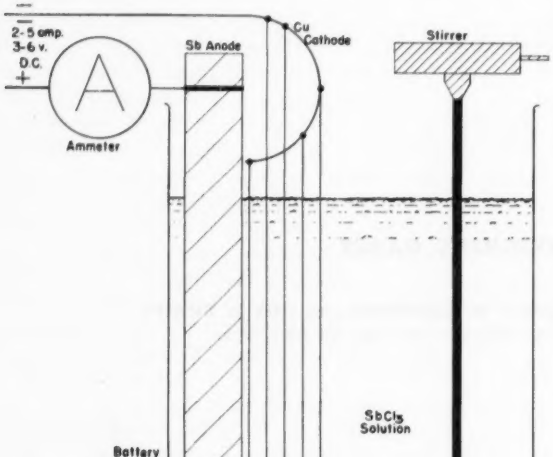


Figure 1

2. Black Antimony. This variety is produced spontaneously from the yellow allotrope by the rapid cooling of antimony vapor, or by the reaction between oxygen and stibine at $-40°$. It is chemically much more active than metallic antimony.

3. Metallic (ordinary) Antimony. This form is definitely metallic, melts at 630°, and has a specific conductivity 4.4 per cent that of silver.

4. Amorphous Antimony. This is the so-called explosive antimony. It is produced by the electrolysis of an antimonous halide using a high current density. It changes "explosively" to the metallic form with the evolution of 2.4 kg.-cal. per gram atom when heated to 200°, scratched, or struck. X-ray diagrams show it to be in the amorphous state,[2] and it always contains some occluded halide.[3] This form is metastable under all conditions. The "explosion" is the result of the heat, produced when the amorphous antimony becomes crystalline, vaporizing the occluded halide, thus causing the fracturing and slight scattering of the metal.

The amorphous variety of antimony may be used to demonstrate a number of phenomena, among which are: that an element may exist in several allotropic modifications; that energy is liberated (or absorbed) in the conversion of one allotrope to another; and of course the fact that there are several allotropes of antimony. The second of these is believed by the author to be the most significant. Although we tell our students that such relationships as

$$P_{(white)} \rightleftarrows P_{(red)} + 4200 \text{ cal.}$$

$$S_{(rhombic)} \rightleftarrows S_{(monoclinic)} - 95 \text{ cal.}$$

exist, we are unable to demonstrate this in any simple, conclusive manner. We may, however, demonstrate the reaction

$$Sb_{(amorphous)} \rightarrow Sb_{(metallic)} + 2400 \text{ cal.}$$

qualitatively quite simply. This system is, of course, irreversible. The only method of preparing amorphous antimony is by electrolysis.

The effects of varying some of the conditions of the experiment have been described by Cohen and Ringer[4]; however, I have given below what I believe to be the optimum conditions for the preparation of this substance.

Apparatus. A power supply unit (such as Cenco #79548) or a source of d.-c. current of from 0.2 to 5 amperes at 3 to 6 volts, a 5-ampere ammeter, a 1-liter battery jar, a small stirrer, copper wire cathodes (B. & S. #18), and an antimony anode. The assembled apparatus is shown in Figure 1.

The cathodes are made of copper wire, and are 20 cm. in length, approximately 8 cm. of which is to be above the solution.

[1] Present address: 1600 Metropolitan Ave., New York 62, New York.

[2] STEINWEHR, H. V., AND A. SCHULZE, *Z. Phys.*, **63**, 815 (1930).
[3] COHEN, E., AND C. C. COFFIN, *Z. Physik. Chem.*, **149**, 417 (1930).
[4] COHEN, E., AND RINGER, *Z. Physik. Chem.*, **47**, 1–28 (1904).

The anode is made by melting lump antimony in a 22 × 175-mm. test tube, and when cool, removing the glass from around the antimony by carefully cracking the former. Attach a copper lead to one end of the electrode, so that it (the copper) will not be submerged into the electrolyte when the cell is operating. Arrange the copper cathodes in a semicircle around the anode, as close to the latter as is practicable, realizing that as the electrolysis proceeds, the cathodes will "grow." A convenient number of cathodes is four or five (Figure 2).

Preparation. To 500 ml. of H_2O, add 300 ml. of concentrated HCl. Dissolve 250 g. $SbCl_3$ in this solution, and add H_2O to make a liter.

Place the anode and cathodes in place, set the stirrer to a slow speed, and electrolyze at a high current density. This should be 0.15 to 0.4 amperes per cm.^{2} of cathode surface. For a #18 copper wire, submerged 12 cm. into the electrolyte, we have a surface of approximately 3.84 cm.^{2} per electrode. With four electrodes, or a surface of 15.4 cm.^{2}, excellent results were achieved using a current of 3 amperes, which is a current density of approximately 0.195 amperes per cm.^{2} of cathode surface. The electrolysis was allowed to proceed for 12 hours. The result was "sticks" of 5 to 7 mm. in diameter. The $SbCl_3$ solution is not appreciably depleted and may be used repeatedly.

The temperature must *not* be allowed to rise above 25°C. and should preferably be kept at 20° or less. Between 25° and 35° a gradual change takes place. An increase in the deposition of the crystalline variety results from an increase in temperature.

Carefully remove and separate the amorphous antimony "rods" and dry them carefully with an absorbent material (Kleenex). Immersion in water will cause the "rods" to become covered with a white precipitate of SbOCl, which will dissolve rather slowly. If it is desired to wash the samples, a dilute solution of HCl in H_2O should be used before immersion in pure water.

Although they change very slowly to the crystalline variety even without outside stimulus, the substance may be preserved for quite a long time without apparent loss in "power," if protected from shock.

Demonstration. The best method of demonstrating this substance in a lecture room is to prop a sheet of asbestos against several boxes (or clamp it in place) at a slight angle from the vertical, and attach the rod of antimony to the asbestos by bending the protruding copper wire over the edge of the asbestos board (Figure 3). Between the antimony and the asbestos, attach a common paper napkin by means of "Scotch Tape."

To cause the molecular rearrangement, one may scratch or strike the stick of antimony, heat it to 200°, or cause a spark to pass from it to an induction coil. The most effective as well as the simplest means, in the authors opinion, to demonstrate this to a class, is to strike the "stick" with the edge of a metal spatula. A relatively light tap will suffice. Instantly the substance will undergo the molecular change, accompanied by a loud hissing sound and dense fumes of antimony trichloride; a few particles are ejected, sometimes glowing. The antimony, after the "explosion," will not have changed much in appearance except for being "chipped," save at points where the most heat is produced, which may be black due to powdered antimony. The napkin will show a black scorch mark the length of the antimony rod, indicating the heat produced. (Sized paper, or even filter paper, will not show this as well as a paper napkin.)

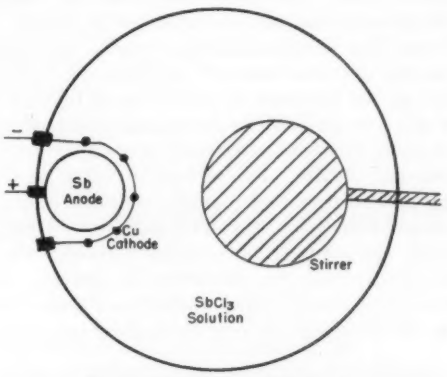
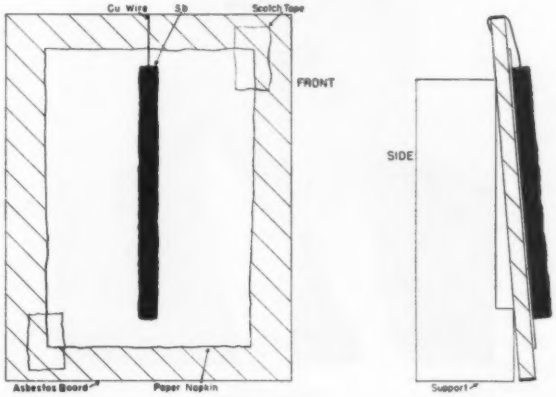


Figure 2. Top View of Battery Jar

One may, if one wishes, show the great thermal energy produced by attaching a piece of cellulose hexanitrate to one end of the rod. It is ignited by the heat produced when the other end is struck.



Front View Side View

Figure 3

The antimony may also be "detonated" below water; however, this would not be visible for as great a distance as the previously described demonstration. The method of presentation will of course vary according to the size of the class, facilities of the lecture room, and preferences of the lecturer.

CLÉMENT DUVAL

RALPH E. OESPER
University of Cincinnati, Cincinnati, Ohio

CLÉMENT DUVAL, whose accomplishments, particularly in analytical chemistry, have brought him international recognition, was born on March 30, 1902, at Neaufles St. Martin, a small village in Normandy. As his parents were very poor, there was no thought of providing more than the essentials of schooling. During World War I, while his father was at the front, the boy worked as wood cutter in the forest, and his spirit rebelled at the prospect of a lifetime of manual labor. He resolved to study alone during the evenings, and by dint of such efforts he eventually passed the bachelor's examination (1920). He served as tutor at various colleges and so prepared himself for a teaching certificate in physical sciences. The ambitious young man attracted the interest of Georges Urbain,[1] who persuaded him to take up chemistry in earnest. During the next three years Duval worked in Urbain's laboratory at the Sorbonne on scandium, the rare earths, and

Clément Duval

inorganic complex compounds. The doctorate dissertation (Docteurès Sciences physiques, Paris, 1927) dealt with cobalt ammines.

After teaching in various schools he was appointed (1936) to a professorship in the École des Sciences at Rouen, where he served until 1943. Here he installed the first course in microanalysis on spot reactions ever given in France. After two years in Germany and Austria as *chef-adjoint* of the scientific mission of the Centre National de la Recherche Scientifique, Dr. Duval was appointed (1946) as Maître de Recherches of the C.N.R.S. He devotes himself almost exclusively to his own researches and those of his students. Each year he offers a course in microanalysis at the Sorbonne. Particularly interesting features of his teaching activity are his courses in technical English and German which are designed for degree candidates just beginning their theses, enabling the students to read the foreign literature with more ease and comprehension and to assemble a bibliography properly. He has published suitable texts for these language courses ("English for the Scientist," "Besser spät als nie," and "Wer sucht der findet").

He has been a member of the Section on new reagents of the International Union of Chemistry since 1946, and as secretary compiled its Third Report which appeared in 1948. Pascal's "Traité de Chimie Minerale" contains 900 pages by Duval on magnesium, thallium, salts and complexes of iron, and platinum ores. Likewise, he contributed 250 pages to the Grignard-Dupont-Locquin "Traité de Chimie Organique." His eleven other books include "Dictionnaire de Chimie et ses Applications," "Manipulations de Chimie," "Notions de Biochimie," "Les Stillireactions," etc.

His scientific achievements are recorded in 170 papers. These may be roughly grouped in four categories.

(*a*) He has attempted to determine the composition of complex compounds in solution by studying the migration of ions. Notably, he has established the structure of organomagnesium compounds dissolved in ether; he has explained the change from red to blue of cobalt salts; the color developed by adding ferric chloride to phenols, etc.

(*b*) With Jean Lecomte he has recorded the infrared absorption spectra of about a thousand inorganic and organic materials. From these data he has established a great many structures, including azides, dithionates, bicarbonates, thiosulfates, acetylacetonates, etc. He explained the isomerism of the complex platinum oxalates and showed that the supposed isomerism of xantho and isoxantho cobalt salts does not really exist. A remarkable fruit of these studies was the discovery of *cis* oxalic acid, and the indication of the existence of oxalic anhydride.

(*c*) In microanalysis, he has discovered and developed several specific spot reactions (gold, copper, ammonia, cobalt) and has devised apparatus for microelectrolysis. He has perfected a new method of differential electrotitration.

(*d*) Since 1946 he has devoted much of his effort to

[1] OESPER, R. E., J. CHEM. EDUC., 15, 201 (1938).

the problem of determining what happens when the various precipitates used in gravimetric analysis are heated. With the aid of the thermobalance he has now examined nearly 1000 materials from this standpoint. He has been able to correct numerous errors and to fix precisely the temperatures of drying, which heretofore have been a matter of pure empiricism. He has invented an automatic method of gravimetry which, without intervention by the operator, permits the determination of two or three materials in mixtures, without separation, and solely by a graphic recording.

Among the prizes and honors that have come to this distinguished French chemist are: Fondation Rosenthal (1924); Fondation Commercy (1924–25); Prix Cahours and Medaille Berthelot (1927); Prix and Medaille Leblanc (1932). He received an honorary doctorate and gold medal from Rio de Janeiro (1935). He has been an officer of the Académie since 1937. His latest distinction (1950) is an honorary membership in the Austrian Microchemical Society.

AN INEXPENSIVE TRANSFERENCE NUMBER APPARATUS

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TRANSFERENCE number experiments in physical chemistry laboratories are usually carried out in the conventional three compartment Findlay apparatus.[1] This equipment costs approximately eighteen dollars per set. With 278 students enrolled in a physical chemistry laboratory course it was desirable to develop a less expensive apparatus from equipment commonly available in a laboratory. We have found that a buret provided with a silver wire cathode located near the upper end and a silver wire anode introduced through the tip of the buret equipped with a rubber policeman serves quite satisfactorily.

Hittorf[2] originally used a vertical tube for determining transference numbers, McInnes[3] describes an experiment employing a vertical tube, and an experiment using a vertical tube is described in a mimeographed manual[4] used at the California Institute of Technology.

The vertical buret type of transference apparatus costs about three dollars, about one-sixth the cost of the Findlay type tube. In addition to the reduction in cost the burets, unlike the Findlay tubes, are used for other experiments throughout the year, do not require special handling or storage for a particular experiment, and are available in quantity in most laboratory stockrooms. The apparatus is not suitable for high-precision determinations, but the results obtained by the students with this apparatus are practically the same as those obtained using the Findlay tube.[5] The use of the described apparatus makes it easy to assign the transference number experiment as an individual student's experiment rather than a "partners" experiment.

Hittorf's original experiments[6] on transference numbers of ions were carried out by the use of vertical tubes the two parts of which could be isolated by sliding sideways. Many designs of glass apparatus have since been used.[7] The apparatus of Jones and Dole[8] is perhaps most satisfactory but its large bore stopcocks and glass joints make it rather expensive for student use. Collins[9] has suggested that rubber connections may be substituted satisfactorily for student experiments.

No invalidating amount of diffusion occurs in the apparatus described if (*a*) reasonable care is taken to eliminate vibration of the tube, (*b*) a glass wool plug is placed

[1] DANIELS, MATHEWS, AND WILLIAMS, "Experimental Physical Chemistry," 3rd ed., McGraw-Hill Book Co., New York, **1941**, p. 234.

[2] LUPKE, ROBERT, "The Elements of Electro-Chemistry," 2nd ed., H. Grevel and Co., London, **1903**, p. 46.

[3] MCINNES, D. A., "Principles of Electrochemistry," Reinhold Publishing Corp., New York, **1939**, p. 62.

[4] Professor R. M. Badger kindly supplied us with this manual. The dimensions of the tube are not given in the manual, but it is probably larger in diameter than a buret and it appears to us that our arrangement is somewhat more convenient.

[5] HOYT, CREIG S., J. CHEM. EDUC., **14**, 472 (1937).

[6] HITTORF, W., *Pogg. Ann.*, **89**, p. 177.

[7] MCBAIN, J. W., *Washington Academy of Sciences Proceedings*, **9**, 1 (1907).

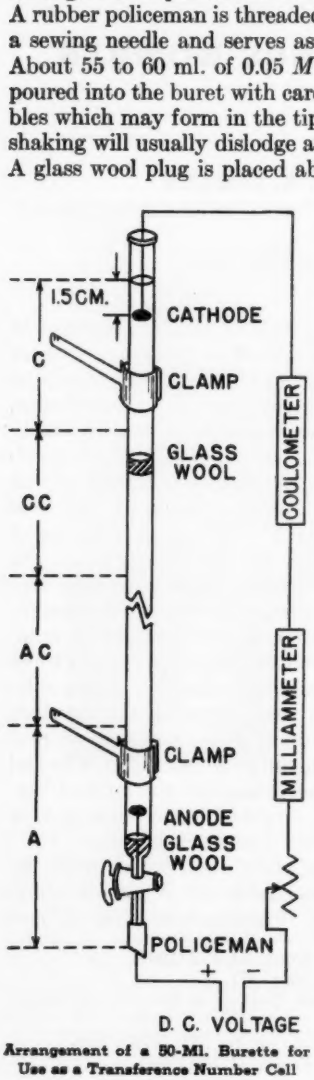
[8] JONES AND DOLE, *J. Amer. Chem. Soc.*, **51**, 1073 (1929).

[9] COLLINS, E. M., J. CHEM. EDUC., **11**, 52 (1934).

beneath the cathode so that any pieces of plated-out silver which fall from the cathode during the experiment are caught before they stir the solution excessively while falling, and (*c*) the region of more concentrated solution after electrolysis is at the bottom of the buret. The anode section is the one least subjected to mechanical mixing during withdrawal and usually gives the best transference number value.

EXPERIMENTAL DETAILS AND PROCEDURE

A 50-ml. buret is placed in two clamps as shown in the Figure. The anode and cathode are made of No. 22 to 27 B. and S. gage wire wound in a flat spiral of as large a diameter as will fit into the buret. A small quantity of glass wool is placed in the bottom of the buret and then the anode is positioned by introducing it into the top of the buret and running the lead part of the anode through the stopcock and finally through the buret tip. A rubber policeman is threaded on the wire by means of a sewing needle and serves as a seal for the buret tip. About 55 to 60 ml. of 0.05 *M* silver nitrate solution is poured into the buret with care to eliminate all air bubbles which may form in the tip of the buret. Vigorous shaking will usually dislodge any air bubbles in the tip. A glass wool plug is placed about 18 centimeters from the top of the solution to prevent any of the cathodic deposition which may become detached from disturbing the solution in the center and anode sections. The cathode is similar in form and material to the anode and is located at the top of the buret, immersed about 1.5 cm. in the solution.



Arrangement of a 50-Ml. Burette for Use as a Transference Number Cell

A coulometer, variable resistor, and milliammeter are placed in series with the buret transference cell, the current is adjusted to 8–10 milliamperes and is allowed to pass for a period of three hours. Any one of several coulometers may be used. We use one consisting of copper-plate electrodes about 1.3 cm. wide and 6.4 cm. long. The cathode is placed between two anodes, each about 1 cm. from the cathode. The electrodes dip into a 125-ml. beaker containing 15 grams of copper sulfate, 5 grams of sulfuric acid, and 5 grams of ethanol diluted to 100 ml. with water.[10] An approximate determination of the cell resistance proved to be about 25,000 ohms. Since our laboratory is furnished with 220 volts d. c., it is not necessary to use a variable resistor. A milliammeter is necessary only to check the current at the beginning of the experiment and may be removed from the circuit. During the time of the electrolysis the original stock solution of silver nitrate is analyzed by Volhard's method.[11]

TABLE I

Data From a Typical Experiment at 25° C.

Equivalents current passed = 0.000872
Stock solution in g. $AgNO_3$/g. H_2O = 0.00869
Normality of KCNS = 0.04760

	Sections after electrolysis			
	A	*AC*	*C*	*C*
Weight in grams	13.45	11.55	12.97	20.58
Ml. KCNS solution used	23.92	12.38	13.78	12.02
G. $AgNO_3$/g. H_2O	0.01432	0.00873	0.00866	0.00439
	Expt. value		*Literature value*[a]	
Transference number of Ag^+ calculated from anode data	0.474		0.477	
Transference number of NO_3^- calculated from cathode data	0.544		0.523	

[a] "International Critical Tables," McGraw-Hill Book Company, New York, 1928, Vol. VI, p. 310.

At the end of about three hours of electrolysis the circuit is disconnected and the anode wire pulled down until it clears the buret stopcock. The stopcock is then closed and the wire and policeman are removed with as little vibration of the buret as possible. The four regions of solution as shown in the Figure (as section A, 14 ml., AC, 14 ml., CC, 14 ml., and C, 15 ml.) are drained into previously weighed 50-ml. weighing bottles at the rate of about 3 ml. per minute. The buret is rinsed with about 5 ml. of original stock solution and added to the bottle containing the cathode solution, C. Weights of the solutions are then determined and the solutions are analyzed by Volhard's method for silver.

The transference numbers are calculated by conventional methods.[12] Two center regions of the solution are analyzed individually to prove to the student that too small a center region has not been selected. The analysis of the two center samples and the stock solution should check within 0.5 per cent.

In Table I are shown the data from a typical experiment.

The apparatus could probably be utilized for the determination of the transference numbers of other ions, but this has not been verified.

[10] DANIELS, MATHEWS, AND WILLIAMS, *op. cit.*, p. 376.

[11] TREADWELL, F. P., AND W. T. HALL, "Analytical Chemistry," 8th ed., John Wiley and Sons, New York, 1935, Vol. II, p. 652.

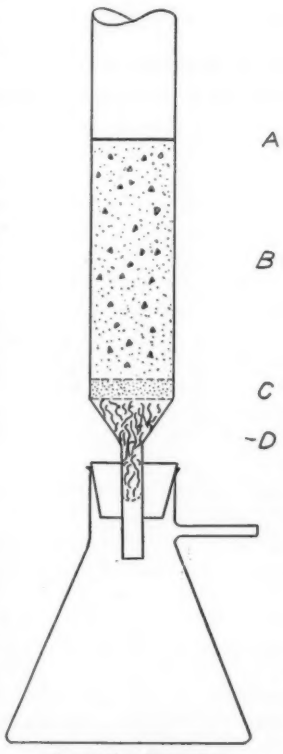
[12] PRUTTON, C. F., AND S. H. MARON, "Fundamental Principles of Physical Chemistry," The MacMillan Company, New York, 1947, p. 436.

A CHROMATOGRAPHIC SEPARATION OF SOME DYESTUFFS

JOHN SHOTT, III and HAROLD W. HEINE
Bucknell University, Lewisburg, Pennsylvania

THE chromatographic adsorption technique first described by Tswett in 1906 is seldom presented in the introductory organic laboratory. A survey of the literature revealed that few of the separations effected can be adapted for student use. For this reason experiments were devised to acquaint the student with the principles of chromatography.

Dyes of unrelated structure were selected for the study because of the ease of separation. Previous investigators[1] have shown that dyes can be qualitatively resolved on adsorption columns and recently Rieman[2] presented a method of chromatographic analysis for estimating small quantities (> 1.0 mg.) of dyestuffs. For the present work it was desired to separate larger quantities of compounds of this type. Activated alumina was employed as the adsorbent, and 95 per cent ethanol and water were used for developing the chromatograms. The dye mixtures investigated were: (1) methylene blue and water-soluble fluorescein, (2) methyl orange and methylene blue, (3) Victoria Blue B and methyl orange.



Separation Apparatus

Excellent results were obtained in each system investigated. Two widely separated bands developed within a very short time and solutions of individual dye components were isolated by continual elution of the column. The total time required to prepare the column, effect the separation, and collect the eluate is three hours.

The apparatus used for the separation is shown in the illustration. The glass column (*A*) was prepared previously by sealing together two lengths of pyrex tubing 8 and 14 mm. in diameter.

The preparation of the column for adsorption is as follows. A plug of glass wool (*D*) is tamped firmly into the constricted portion of the adsorption tube and covered with a layer of sand (*C*) not more than 5 mm. thick. After the sand has been leveled off by gentle tapping of the tube with a ruler or dowel, the adsorbent mixture (*B*), prepared by shaking together in a wide-mouthed bottle 28 grams of activated alumina (Aluminum Company of America) and 2 grams of Hyflo Supercel (Johns-Manville), is added slowly and with continued tapping to the tube. Half the quantities of alumina and filter-aid recommended above also gave excellent results. The tapping process insures an evenly packed column.

A piece of filter paper of the same diameter as the column is cut and gently placed on the adsorbent so that the surface of the alumina will not be disturbed by the elution process.

The column is now washed with 95 per cent ethanol and suction is gently applied. Eluant is continually added so that the top of the column never runs dry. The water aspirator is adjusted so that the rate of flow is about 15 drops per minute. When the first drop of eluate falls into the receiver, the column is ready for use. The eluate is allowed to come within 1 mm. of the top of the alumina at which time the dye is added all at once. When the dye solution is 1 mm. above the adsorbent, the top of the tube is rinsed with 2 cc. of ethanol.

SEPARATIONS

Water-Soluble Fluorescein and Methylene Blue. This separation offers no difficulty. Five mg. of water-soluble fluorescein (Coleman and Bell Co.) and 5 mg. of methylene blue (J. T. Baker Chemical Co.) are placed in a 4-inch test tube and dissolved in 3 to 4 cc. of 95 per cent ethanol with vigorous shaking to insure solution of the dyes. Ethanol is used as the developer. The water-soluble fluorescein is held tenaciously by the alumina while the band of methylene blue begins to separate almost immediately. The separation is continued until the eluate dropping into the receiver is colorless. The receiver is emptied and water is now used as the eluant. The water-soluble fluorescein immediately migrates down the column.

Methyl Orange and Methylene Blue. This separation can be achieved by developing the column with ethanol. One mg. of methyl orange and 5 mg. of methylene blue are dissolved in 2.2 cc. of ethanol. The dye mixture is shaken very thoroughly before pouring on the column. The methyl orange is adsorbed more strongly than the

[1] RUGGLI, P., AND P. JENSEN, *Helv. Chim. Acta.*, **18**, 624 (1935).
[2] RIEMAN, WM., J. CHEM. EDUC., **18**, 131 (1941).

methylene blue. It can be collected by eluting the column with water after the methylene blue has passed into the receiver.

Methyl Orange and Victoria Blue B. One mg. of methyl orange and 5 mg. of Victoria Blue B are dissolved in 2.2 cc. of 95 per cent ethanol. The chromatogram is developed with ethanol. Methyl orange again possesses the stronger adsorption affinity and is located near the top of the column. It may be eluted with water.

MORE RELIABLE LETTERS OF EVALUATION

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The Johns Hopkins University, Baltimore, Maryland

EACH year many chemistry teachers are deluged with requests for letters of recommendation. The necessity for these adjuncts to application forms is well known. The acquisition of reliable information for composing these "letters of evaluation" (a preferable term) is at best a difficult task, particularly in the large college or university department of chemistry.

The present large classes make it practically impossible for the instructor to learn anything about the personal characteristics of his students, with the exception of the few who are requested to confer with him or who do so by their own request. The average, hard-working student, whose personal attributes may be a stronger recommendation than his grades, is not usually in this group. If these strong personal characteristics are not pointed out in a letter of evaluation the author of the letter is guilty of an injustice to the student.

From a slightly different viewpoint, who will be able to write a just letter for the premedical student or other nonmajor who finds that all of his former chemistry instructors have left the institution? This situation develops where the elementary courses are taught by temporary instructors or in those institutions which have a considerable turnover in the lower ranks of the faculty.

The usual letter of evaluation is too often based on the observations of the instructor and the laboratory assistants in only one course. Such a practice, even under the most favorable circumstances, may not produce an adequate appraisal of the student's intellectual and personal attributes. However, a departmental letter based on the student's performance in all of his courses in this department will give a more reliable evaluation of his ability and personal characteristics.

The author has had this job of writing departmental letters of evaluation in the Department of Chemistry at the Johns Hopkins University for the past four years. At the time he was charged with the job the placement bureau of the university was unable to furnish the department with character sketches of the students. Therefore, he installed and put in operation a card system for gathering, recording, and reporting the instructors' and the laboratory assistants' opinions concerning the students' personal attributes, capabilities, and caliber of work. This record system has not proved onerous to the faculty or burdensome to the department. The record system not only provides a solution to the previously mentioned problems but is also useful for maintaining a permanent record of the work and character of each student, for quickly checking the relative standing of any particular group of students, and as a source of reliable information for composing departmental letters of evaluation.

The core of this system is a four-by-six inch printed card, as shown. The card is designed to allow a large portion of the work to be done by secretarial help. The secretary prepares a card for each chemistry course a student is taking by writing in his name, checking the appropriate square in space (1) and using rubber stamps to complete the spaces marked with a star. The

cards are then given to the instructors for distribution to their laboratory assistants.

In courses having large enrollments the backs of the cards are filled in by the laboratory assistants, who, by their closer personal contact with the students, are in a better position than the instructor to evaluate the students' personal characteristics. In courses having small enrollments the cards are made out by the instructor. At the beginning of the year the assistants are given sample cards and the system is explained to them. To make their evaluations as reliable as possible it is suggested that they use as their final values an average of several evaluations made at intervals throughout the term. In most year courses it is possible to give each assistant a different group of students for the second term, thereby securing a second set of evaluations from one course.

The spaces entitled "Remarks" are used by the laboratory assistants and the instructors to record in a few words any incidents that have occurred or any pertinent comments that vividly portray the student's characteristics, aptitudes, or capabilities, regardless of whether they have been evaluated elsewhere on the card. If the course is a combined lecture and laboratory course the instructor may have his assistants indicate the laboratory ability of the student by an appropriate grade in space (2). The grade for the course and the rank of the student in the class are added to complete the card.

The completed cards are filed by courses in the departmental office. After the second term's work has been added they are placed in an alphabetical file. After the student graduates or leaves school his cards are removed and placed in an inactive file. This keeps the active file at a convenient size.

In addition to the above cards the author uses a supplemental method for obtaining an over-all view of the student's work. His secretary, on receiving a request for a letter, fills in a printed form which covers the following points: (1) the name of the student, (2) to whom and for what purpose the letter is to be written, (3) a list of the student's extracurricular activities and offices held in each, summer jobs, etc., (4) the secretary's evaluation of the student's appearance and personality, and (5) the student's grades, as obtained from the registrar's records, in all of his other science courses, and his approximate over-all college average.

The author, on receiving the above printed form, along with the record cards from each of the student's chemistry courses, writes the letter of evaluation. At times a personal interview with the student is used as an additional aid in securing information. The letter of evaluation covers the following points: (1) the names of the courses taken, the year in which they were taken, the term grades and the standing of the student in each course; (2) his approximate average in his other science courses; (3) his approximate over-all college average; (4) the consensus of his instructors and laboratory assistants concerning his personal attributes and his laboratory manipulative skill; (5) a brief statement as to his extracurricular activities; and (6) a statement of the author's opinion of the student as a candidate for admission or as an applicant for a job.

NAME: YEAR: ★

COURSE: ★ COURSE NO. ★

	FIRST TERM	SECOND TERM
CHECK ONE OR BOTH ① LECTURE ☐ AND/OR LABORATORY ☐	②	②
COMPOSITE GRADE FOR WHOLE COURSE		
RANK IN CLASS	RANK / NO. IN CLASS	RANK / NO. IN CLASS
NAME OF INSTRUCTOR	★	★
NAME OF LABORATORY ASSISTANT		

REMARKS- FIRST TERM

Record Card (Front)[1]

In the case of a superior student who has taken junior and senior courses in chemistry it is customary to send his records, along with a copy of the departmental letter, to another faculty member who has the student currently in class. This faculty member is requested to write a note re-emphasizing the capabilities of the student. Copies of all letters and the printed form are filed in the departmental office while the record cards are returned to the appropriate file.

MARKED ON BASES OF: 5 - SUPERIOR; 4 - BETTER THAN AVERAGE; 3 - AVERAGE; 2 - WORSE THAN AVERAGE; 1 - VERY POOR

	1ST TERM	2ND TERM
RELIABILITY		
ORIGINALITY		
PERSEVERANCE		
INITIATIVE		
COMMON SENSE		
COOPERATION		
MANIPULATIVE SKILL IN LABORATORY		
PERSONALITY		
APPEARANCE		
AS APPLICANT FOR: MEDICAL SCHOOL		
GRAD. WORK IN CHEMISTRY		
CHEM. EMPLOYMENT		

REMARKS: SECOND TERM

Record Card (Back)[1]

In four years of operation this system has saved the author innumerable hours as compared to other methods used in the past. The reliability of the letters of evaluation has been greatly improved. They give a more accurate picture of the student than those based on his performance in only one course.

[1] The next printing of these cards will have the following changes: "Composite Grade for Whole Courses" will be changed to "Composite Grade for Each Term," "Better Than Average" to "Above Average," and "Worse Than Average" to "Below Average."

AN IMPROVISED ULTRAMICROSCOPE

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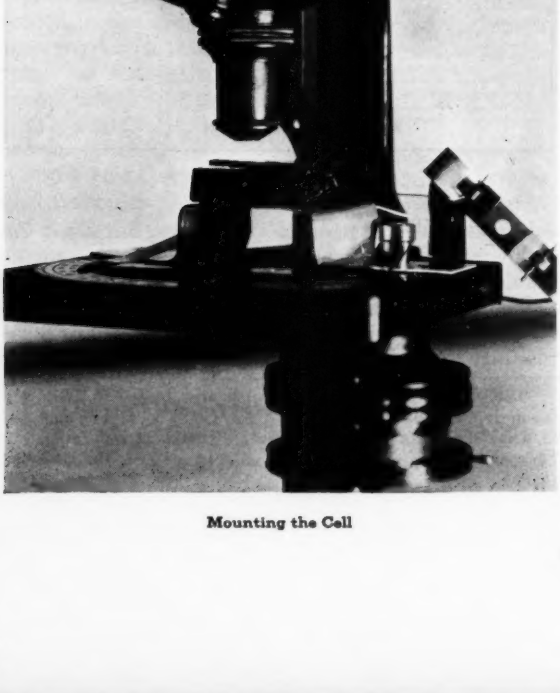
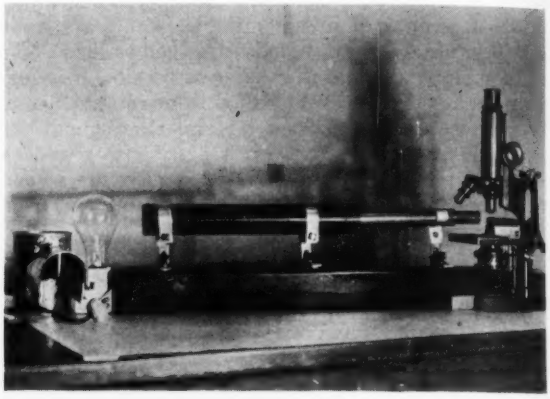
THE ultramicroscope is an effective device for demonstrating the probability of molecular motion by its revelation of the Brownian movement. The instrument herewith described and illustrated is easy to assemble and adjust, and the lens system is efficient and relatively inexpensive. This arrangement has the advantage of enabling one to determine the character of the charge on the colloidal particles under observation.

The materials required are as follows: one ordinary 100-watt Westinghouse straight-filament clear glass lamp; a two-foot length cut from a square-tube steel garage door track (the latter makes an excellent optical bench when properly supported); six $1^1/_2$ inch washers; six 2-inch bolts with thumb nuts and washers; three small right-angle irons; cardboard, brass, or copper tubing; some tin or aluminum strips for the tube holders; lamp sockets; a couple of tin cans for the lamp shield; lamp cord and plug; a few wood screws; two achromatic lenses, 32 mm. diameter and 171 mm. focus, and one achromatic lens 18 mm. diameter and 35 mm. focus. Such lenses can be purchased from war salvage firms for about three dollars.

A piece of wood is cut of such size that it will fit closely in the lamp end of the track section and extend out a few centimeters. The lamp socket is mounted on this extension.



Mounting the Cell



Complete Assembly

The tubes are supported with metal strips, angle irons, and bolts as shown in the photograph. Slots cut in the angle irons permit a vertical adjustment of the light beam. The microscope shown here is a rebuilt Bausch and Lomb instrument of moderate cost. The track section is slipped between the prongs of the microscope base and two wood wedges serve to hold the track and microscope in firm alignment.

No slit is used in this instrument. Instead, the reduced image of the straight line lamp filament is projected into a thin film of colloidal solution held by capillary attraction in a cell of special design.

This cell and mounting consists of the following elements. A strip of sheet metal about 4 cm. wide is bent, as shown in the diagram, to form a shelf-like superstage. A piece of black glass, bakelite, or ordinary glass plate, 4 cm. square, is cemented to the top. If ordinary glass is used, it should be painted black on the bottom and edges.

Two parallel wires are attached to the glass plate by cementing them to the glass at the rear end of the superstage and of sufficient length to extend out for battery connections. We use #28 chromel wire, but platinum wire would be better. These wires must lie flat on the glass. A cover glass laid across them forms a thin rectangular cell open at the front to the beam of light. The edge of the cover glass must come even with the front edge of the black glass plate. The edge of the former should also be blackened. A few drops of the colloid solution suffice to fill this cell.

The wires permit the use of a battery to determine the sign of the particle charge. For example, a colloidal solution of sulfur was prepared by dissolving 2.48 grams of sodium thiosulfate in 10 ml. of water, then adding

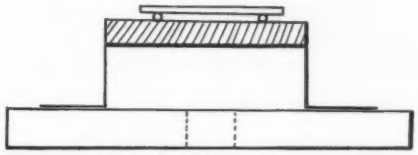
some HCl gas by blowing across the top of an unstoppered bottle containing concentrated HCl solution. As soon as the solution became cloudy it was diluted to 100 ml. yielding a tenth-molar solution.

When this solution was placed in the cell and properly illuminated three $1^1/_2$-volt cells connected in series with a key and low resistor were connected to the cell. On closing the circuit through a resistance of one ohm the sulfur particles moved rapidly toward the positive pole, thus revealing their negative charge.

A piece of polaroid film laid over the eyepiece of the microscope often will give a clearer field by cutting off the light polarized by reflection.

The total cost of this equipment, the microscope excepted, should be less than ten dollars. In conclusion, it should be pointed out that there is nothing critical about the lens system used for illumination. Any arrangement that will project a bright and sharp image of the lamp filament into the cell will prove entirely satisfactory.

Cell Construction



TESTING THE OUTCOMES OF CHEMICAL EDUCATION[1]

BEATRICE LEVY
Educational Testing Service, Princeton, New Jersey

THE Educational Testing Service is a young organization engaged in the full-time occupation of educational testing. Within the organization there is a Test Development Department through which all tests make their way while progressing from an idea to the finished product. Within the Test Development Department are sections for such subjects as mathematics, science, social studies, and humanities. Each section consists of persons with advanced training in their respective fields, experience in teaching, and some experience in the field of testing.

A test first reaches the Test Development Department when in the planning stage. Specifications regarding its purpose, contents, and format are generally made by the contracting agency (for example—Association of American Medical Colleges, for whom we prepare the Medical College Admission Test) in consultation with an ETS project director who maintains the overall responsibility for the test. A committee of examiners is then appointed. I should like to emphasize that ETS places considerable stress upon the system of committees for all of its test programs.

Members of the examining committees are all experienced teachers who are active in their particular fields. These people are recommended by the contracting agency or professional societies, or they are people with previous experience in testing. Because ETS tests are administered on a nation wide basis, the geographical representation of the membership is also considered.

The committee of examiners, working with the contracting agency and ETS, draws up the plan of the test, makes an outline of the material to be covered, and then proceeds with question-writing. Two to three times more test questions are prepared than will be used, allowing for the failure of some questions during pretesting and permitting some flexibility during the assembling of the test. Pretesting is almost a self-defined word. It is literally a test "before" the test. The newly written questions are edited for spelling, grammar, punctuation, capitalization, consistency, improvement of style, and clarity. Then they are assembled into tests which are administered to groups comparable to the population that is ultimately going to be tested. If it can be assumed that the characteristics of this pretest population are the same as those of the regular population, certain statistical processes may be applied to the test results to determine the testworthiness of the new questions. In this way poor questions may be discovered and removed. A good question is one which is answered correctly by people who do well on the whole test but is answered incorrectly by those who do poorly on the whole test. The statistical measure of this tendency is called the biserial r, and questions which have a biserial r lower than $+0.30$ (where the maximum r is $+1.00$ and the minimum is -1.00) are generally discarded.

From the batch of questions which survive the ordeal of pretesting, the committee assembles a final form. This final form is submitted to close scrutiny by a member of the subject-matter section who makes certain that no duplication of questions or gross errors

[1] Presented at the 118th Meeting of the American Chemical Society, Chicago, Illinois, September, 1950.

have slipped into the test during the process of assembling, that the subject-matter coverage is complete, and that there is an adequate range of difficulty levels. Answer keys are prepared by both the committee and ETS and are checked very carefully by all concerned. The test is given a second quick editing to catch errors which may have slipped by during the first. After copy is prepared it is reviewed again, and when the final printing is complete the test receives another complete review and keying. It is now in a form ready to be administered for the purpose for which it was intended.

A. C. S. CHEMISTRY TESTS

The purposes for tests are many, but the one in which we are most interested here is to test, for one reason or another, the degree of achievement in the field of chemistry. Many of the ETS programs include chemistry tests. The only tests which are available for purchase by colleges generally, however, are the Cooperative Tests, which include the A. C. S. series. This series consists of tests in each of the following areas of college chemistry: general chemistry, qualitative analysis, quantitative analysis, organic chemistry, physical chemistry, and biochemistry. A set of percentile rankings or norms are provided with each test. Mr. William Angoff of the Statistical Analysis Department has written a few lines explaining norms which I should like to present.

Any mental test may be considered an instrument of measurement. One important difference between mental and physical instruments of measurement is that the scales of measurement for so-called mental properties are much more numerous and varied than are those in the area of physical measurement. Consequently, a measurement, that is, a score on a mental test of, say 43, means nothing in itself, unless additional data are given for use in evaluating that measurement. Similarly, additional data must be provided to aid in the evaluation of total class performance. It is for these purposes that norms are established. Ideally, a set of norms for a test should be based on a well-defined population whose characteristics are known to the test user and are similar to those of the group of people whose performance he has measured. In the practical situation, however, particularly in the case of the A. C. S. Chemistry tests, the students taking the tests are so heterogeneous that no well-defined population can be established for norms purposes. As a reluctant compromise Educational Testing Service makes use of all available test results and sets up norms for as many separate, homogeneous groups as the available numbers of cases warrant. This means separate norms for students taking one- and two-semester courses, for students receiving different amounts of lecture and laboratory training per week, etc. Naturally, reliable norms cannot be established unless the tests are administered in the way prescribed by the publishers and unless the papers are accurately scored. Obviously, if each institution administers the test and scores its papers differently, the resulting norms are meaningless. In fact, it is evident that schools must always score their answer sheets correctly if they are to make appropriate comparisons with norms. In the 1949 National Chemistry Testing Program, so many errors were found in the returned answer sheets that complete rescoring had to be done in a large percentage of the cases. Also, many schools had to be omitted from the norms because insufficient information had been supplied regarding the type of course given. Educational Testing Service relies entirely on the cooperation and wholehearted response of the participating colleges in the A. C. S. Chemistry Program. Without this cooperation we cannot provide you with the kind of reference data we want to prepare and the kind you need to evaluate the performance of your students.

A teacher may use the results of these tests in a variety of ways: as one criterion for judging student performance, as a means of comparing the effectiveness of a course with similar courses given elsewhere, or as an indication of the success of his teaching. No demands are made upon the test consumer after he has purchased the tests other than the type of cooperation which Mr. Angoff mentions.

OTHER TEST OFFERINGS IN CHEMISTRY

Most of our programs, however, are not released to the general test-using public but are maintained with the strictest security. These tests are prepared, analyzed, published, administered, scored, and reported by ETS. Probably the most well-known program with a chemistry test is the College Entrance Examination Board series. These tests are administered to high-school students to evaluate their secondary-school preparation for entrance into college. Each candidate takes both an aptitude test and one or more achievement tests.

The achievement test in chemistry is one hour long. A standard secondary-school course in the field, including both classroom and laboratory work, is considered to be adequate preparation for this test. Test results are reported on a standard scale on which a score of 500 represents the typical candidate. Two-thirds of all students score between 400 and 600. The test is, as I have stressed before, a product of the joint effort of the Board of Examiners in Chemistry (the committee) and the chemistry test technician of ETS. The Board committee is composed of three college chemistry teachers and two high-school teachers. A balance is thereby achieved between two mildly divergent schools of thought about the purpose of a high-school chemistry course and what is to be expected of students who have finished it.

At the college graduation level ETS sponsors the Graduate Record Examination which tests college graduates in the same way as the College Board tests high-school graduates. Its main purpose is the evaluation of a student's fitness to pursue graduate studies, as evidenced by aptitude, integration of background, and proficiency in his major subject and related minors. The Advanced Test in Chemistry of the GRE is a three-hour survey of the areas of chemistry generally covered in an undergraduate chemistry major. The range of difficulty of the test items varies from questions which can be answered by a first-year student to questions which can be answered using material given in elementary graduate chemistry courses. The test is assembled from questions written by an examining committee of five specialists in the field of chemistry—four college teachers and a research chemist with years of teaching experience. Results are scaled by the method employed with the College Board tests (that is, with a score of 500 representing the typical candi-

date), and scores are reported in the same way. Competent authorities in the field of chemistry have suggested that this same test might prove useful as a final comprehensive examination for schools which do not now test their chemistry majors.

The Medical College Admission Test and the National Teacher Examinations also contain chemistry questions. Because of the general nature of these programs, chemistry achievement is tested in conjunction with one or more of the other sciences. More stress is placed upon aptitude in science than upon achievement in any one field.

TYPES OF QUESTIONS[1]

The most commonly used questions in objective testing are the five-choice or completion 1–5 items. They are the most versatile type at our disposal. Skillful arrangement of words in the premise (statement or question) and of the words in the choices offers the test constructor a variety of possibilities. They are most easily constructed to test recall of specific information but may be designed to require reasoning and understanding in order to arrive at the correct answer. The following samples are ways in which this type of item may be used in chemistry tests.

Completion 1–5

Recall of information	1. The atomic number of fluorine is (A) 6, (B) 7, (C) 8, (D) 9, (E) 10
Application of information	2. A sodium atom and a sodium ion (A) contain the same number of electrons, (B) have identical nuclei, (C) have the same physical properties, (D) are isotopes, (E) differ in the number of protons they contain
Laboratory observation	3. In the laboratory preparation of hydrogen from zinc and dilute sulfuric acid (A) manganese dioxide is used as a catalyst, (B) the gas is collected over water, (C) the resulting solution is green, (D) the gas is heavier than air, (E) the mixture is heated to boiling
Numerical problems	4. The weight, in grams, of KOH required to prepare 11.9 grams of KBr by the reaction, $6KOH + 3Br_2 \rightarrow 5KBr + KBrO_3 + 3H_2O$ is (A) 6, (B) 6.72, (C) 56, (D) 67.2, (E) 336

The present trend in educational testing is to place emphasis upon the application of basic knowledge to various situations. Four different types of questions are given below which are now in use for testing that sort of ability.

First there is the classification-type question which involves the association of an idea with one of several key headings. Two main varieties of this type are used: the five-choice type in which five different key headings are used and the four-choice type in which two key headings are used, together with the headings "both" and "neither." The illustrated example is a five-choice one. This item type has the advantage of taking little time to cover a great deal of material and of providing a maximum number of scorable units in a given length of time. It is particularly useful in chemistry since simple diagrams, symbols, principles, laws, or graphs are well suited for use as key headings.

Classification 1–5

Directions: Each group of questions below consists of five lettered headings followed by a list of numbered words or phrases. For each numbered word or phrase select the one heading which is most closely related to it. Indicate your selection on the appropriate line of the answer sheet by blackening the space under the letter of your choice.

I.
(A) Fluorine
(B) Chlorine
(C) Bromine
(D) Iodine
(E) Benzine

1. Compound
2. Lightest element of the halogen series
3. Dark-red liquid
4. Forms an acid which etches glass
5. Creates intense blue color when added to starch
6. Low-boiling naphtha

II.
(A) Hypothesis
(B) Problem
(C) Principle
(D) Observation
(E) None of the above

1. The barometric pressure today is 776 mm. Hg.
2. Since the barometer is steadily rising the weather tomorrow will be clear.
3. Mercury has a density of 13.6 g./ml.
4. The volume of a gas varies inversely with the pressure.
5. The symbol for mercury is Hg.

The second type is the comparison type. These items are used to test the understanding of the student of quantitative relationships on the one hand and of chronological relationships on the other. Both types require that the student have a firm command of basic principles and that he be able to integrate his knowledge before arriving at the correct answer.

Quantitative Comparison 1–3

Directions: The following paired statements describe two entities which are to be compared in the quantitative sense. On the appropriate line of the answer sheet blacken the space under

A, if the entity described on the left *is greater than* that on the right;
B, if the entity described on the left *is less than* that on the right;
C, if the left and right are *approximately the same.*

1.	The volume occupied by one gram molecular weight of helium at standard conditions	The volume occupied by one gram molecular weight of oxygen at standard conditions
2.	The concentration of oxygen in the right auricle of a mammalian heart	The concentration of oxygen in the left auricle of a mammalian heart
3.	The concentration of barium chloride in a one-molar solution	The concentration of barium chloride in a one-normal solution

The third type is the Supplemented Paragraph Comprehension, in which a technical paragraph, table, or graph is followed by a series of statements. The stu-

[1] CAYNE, BERNARD S., AND JOHN W. LANDIS, "Sample objective questions in science," Educational Testing Service, 1950.

dent is asked to classify each of the statements according to whether it may be warranted by the presented material, contradicted by it, true but not warranted by the material, or contradicted by evidence other than that in the material. This type of item was developed to test real comprehension of scientific material in contrast to mere reading ability. The type also requires the student to judge whether the statement is actually warranted by the facts presented and thus tests his ability to remain within the facts.

Supplemented Paragraph Comprehension 1–4

Directions: In this part of the test there will be several passages each followed by a series of statements. Read the pasage and then classify each of the statements under one of the following categories:

(A) The statement is warranted by information given in the passage.
(B) The statement is true but not warranted by the passage.
(C) The statement is contradicted by the passage.
(D) The statement is contradicted by other established evidence.

Passage:

The only carbohydrate which the human body can absorb and oxidize is the simple sugar glucose. Therefore, all carbohydrates which are consumed must be changed to glucose by the body before they can be used. There are specific enzymes in the mouth, stomach, and small intestine, all the other monosaccharides are changed to glucose by enzymes secreted by the intestinal glands, and the glucose is absorbed by the capillaries of the villi.

The following simple test is used to determine the presence of the monosaccharides. If Benedict's solution is added to a solution containing glucose or one of the other monosaccharides and the resulting mixture is heated, a brick-red precipitate will be formed.

This test was carried out on several substances and the information in the following table was obtained. "P" indicates that the precipitate was formed and "N" indicates that no reaction was observed.

Material tested	*Observation*
Crushed grapes in water	P
Cane sugar in water	N
Corn syrup	P
Molasses	N

Statement:

1. Grapes contain monosaccharides.
2. Cane sugar is absorbed from the small intestine.
3. The body uses sugar for energy.
4. Molasses is a good source of protein.
5. Corn syrup must contain glucose.

The last type is the cause-and-effect question, which is used in comparatively high-level examinations to test both knowledge of subject matter and understanding of what is involved in the cause-effect relationships of a situation.

Cause and Effect True-False 1–5

Directions: Each of the following sentences consists of two main parts: a statement and a reason for that statement. On the appropriate line of the answer sheet blacken the space under

A, if both the statement and the reason are true and are related as cause and effect;
B, if both the statement and the reason are true but not related as cause and effect;
C, if the statement is true but the reason is false;
D, if the statement is false but the reason is an accepted fact or principle;
E, if both the statement and the reason are false.

1. If the pressure of a gas remains constant, the volume of that gas will vary directly with the absolute temperature because the kinetic energy of the molecules of the gas is dependent upon the amount of heat energy available.
2. The U-235 atom undergoes fission when bombarded by neutrons because the neutrons destroy the meson bonds.
3. Chlorine and fluorine are in the same group in the periodic table because they were placed there by Mendeleev.

Frequently, during discussions concerning objective testing, the criticism has been made that testing agencies do not keep abreast of the new developments in education. ETS is aware of this challenge and for this reason maintains constant touch through attendance at professional meetings and through its committees who serve as a continuous liason between ETS and the general field of education.

ALTERNATIVE METHOD FOR THE PERKIN REACTION

Dr. K. C. Pandya, Professor of Chemistry at St. John's College, Agra, India, has suggested an alternative method for the preparation of cinnamic acid to the one given by R. E. Buckles in our last April issue.[1]

According to Dr. Pandya's method,[2] 1.06 g. of benzaldehyde, 1.05 g. of dry malonic acid, and 0.13 g. of freshly distilled pyridine were mixed and heated together on a water-bath for four hours, when white crystals of cinnamic acid were formed. They were extracted by treatment with sodium carbonate followed by precipitation by means of a mineral acid. The product melted at 133° and weighed 1.4 g., which represents a yield of 94.6 per cent.

Dr. Pandya has used this method successfully with more than 24 different aromatic aldehydes.

[1] BUCKLES, R. E., "The use of the Perkin reaction in organic laboratory classes," J. CHEM. EDUC., **27**, 210 (1950).

[2] PANDYA, K. C., AND R. B. PANDYA, *Proc. Indian Acad. Sci.*, XIV, 116 (1941).

REPORT OF A SEMINAR ON THE GENERAL SCIENCE COURSE IN HIGHER EDUCATION

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THE seminar in the natural sciences at the Workshop in Catholic Higher Education for Women, held at Loretto Heights College in Denver, attacked the now well-worn problem of the place of the sciences in a general education with a technique designed to stimulate interest of a vital nature. Instead of viewing the situation from the stand of the educationists and fitting science into the general pattern, the seminar members approached the question from the viewpoint of the scientists and discussed the debatable answers to: "What part do general education science courses play in a science curriculum?"

The hue and cry of many nonscience faculty members have been that it is the science major who is not "generally" educated. This matter has been well refuted in an article by Doctor Van Evera of George Washington University,[1] and was not on the agenda of the science seminar since the members were all of one mind, agreeing with Dr. Van Evera that the science major with his requirements in history, sociology, economics, and English is probably a far more broadly trained man than is his classmate who has almost no science.

However, the workshop group appreciated the fact that the broad overview of the natural sciences, as presented by the general course, was of significant value to the science major, along with the required elementary science courses, and consequently studied the problem of how to fit the science general course, or the achievement of its broad objectives, into the science curriculum.

There appeared to be three methods for attaining this end:

(1) All students, whether science majors or nonscience majors, would take the science general course. In the second year the science major would start his sequence of major studies. This would necessarily minimize the amount of specialization a science major could undergo. As to the benefits or detriments derived from such a procedure there were many pros and cons. This method is being used at various colleges, among them, St. Xavier's college in Chicago.

(2) In this method, all students would take a science general course geared to the presentation of a basic, over-all view of one science. The course would not be a survey type but would contain the essential elements of one science well knit together. At the end of such a course, which could be terminal at the end of a semester, the science major would continue to build his major sequence. His next course would simply be a broadening and a deepening of the first. It would presume on the knowledge gained from the first course, and consequently no valuable curriculum time would be removed from the specialization period of the science major. Something along this line is being done in the chemistry department of St. Louis University.

(3) In the last method, the science major would take the elementary course in his major field and would not take the general course in science. Then during his senior year he would participate in a seminar which would integrate his major studies with related sciences and with other fields. This would permit him to gain that over-all view of science and science relationships essential to a real understanding of any natural science.

A considerable time during the seminar meetings at the Workshop was devoted to a study of various general courses. Methods of approach and pedagogical techniques were analyzed, and courses of study examined. Evaluation techniques were discussed during one session under the capable direction of Dr. Chester Harris of the University of Wisconsin. The pertinent question of the training of faculty to man the science general courses was raised time and again. The consensus of opinion prevailed that the value of the general course depended on the faculty member presenting the course. Finally, the formal report of the seminar was offered to the general assembly in the form of a panel discussion, the outline of which follows:

I. What is our problem as science teachers?
   Objectives of science.
   Needs of students.
II. What is the traditional pattern in science?
   What are the trends in the science curricula?
III. What is the place of general education in the science curriculum?
   Methods of approach in general courses.
   Techniques.
IV. How is the teacher to be prepared for general education in science?

In discussing the training of teachers for general education courses special reference was made to the present program at St. Louis University, which offers a Master's degree in Chemistry Education and is in the process of formulating a curriculum for a Ph.D. degree especially designed for the future teacher of general education courses.

[1] VAN EVERA, BENJAMIN D., "Chemistry and liberal education," *Chem. Eng. News*, XXVI, 446 (February 16, 1948).

Proceedings of the

PACIFIC SOUTHWEST ASSOCIATION OF CHEMISTRY TEACHERS

SECOND ANNUAL MEETING

THE Pacific Southwest Association of Chemistry Teachers held its second annual meeting in Los Angeles area on November 3–4, 1950, and representatives from every part of California participated in the two-day program. Philip Gill, Glendale City College, Chairman-Elect of the Southern California Section of the PSACT, was chairman of the program committee.

Friday evening, November 3, the Association participated in the Southern California sectional meeting of the American Chemical Society, held on the campus of the California Institute of Technology. Following the dinner, the general meeting was addressed by Dr. L. Zechmeister, Professor of Organic Chemistry at the California Institute of Technology, on the subject, "Some problems and applications of chromatography." Dr. Zechmeister, an eminent authority in this field and author of a book and many research papers on chromatography, reviewed its recent applications to problems in the separation of organic isomers and in the elucidation of the chemistry of marine life. Immediately after the general session, the assembly broke up to attend group meetings, one of which was sponsored by the Pacific Southwest Association of Chemistry Teachers for its own members. The principal speaker at this session on chemical education was Dr. J. B. Ramsey, University of California at Los Angeles, who discussed the history and development of the first-year chemistry course at U.C.L.A. With the aid of mimeographed outlines, Dr. Ramsey discussed the choice of subject matter and texts, the interrelationship of lectures, laboratory work, and recitations, and the policies of their department in instruction, testing, grading, etc.

On Saturday, November 4, the Association met for a very full day of activities on the campus of the University of Southern California. Dr. Arthur Furst, President of the Association, opened the morning program and presided at the panel discussion on "The sequence of topics in general chemistry." Leading the discussion were: Dr. K. J. Mysels, University of California; Dr. N. Davidson, California Institute of Technology; and Dr. W. C. Pierce, Pomona College.

An entirely new sequence in the presentation of the subject matter of general chemistry was presented by Dr. Mysels, developed by himself and Dr. Charles S. Copeland for a rigorous, terminal course for electrical and mechanical engineers who have a serious interest in chemical principles. Dr. Davidson discussed the purposes for the order used in teaching the general chemistry at the California Institute of Technology. He brought out the importance of sequence in laboratory work, in which experiments illustrating one principle may involve the understanding of more advanced material than can be presented profitably at the time. Dr. Pierce outlined a new program, affecting the distribution of time and subject matter in the first two years, which is being tried this year at Pomona College.

The afternoon program consisted of the following papers:

"The Fulbright Fellowships, especially those of interest to chemists," by Dr. Howard Benninghoff, City College of San Francisco. Since Dr. Benninghoff was unable to attend, his paper was read by the Secretary, Valerie Phillips, San Francisco Junior College.

"The Chicago A.C.S. Meeting," by Dr. Harper Frantz, Pasadena City College. Dr. Frantz commented on the highlights and his own personal impressions of the 118th Meeting of the American Chemical Society and the 6th National Chemical Exposition; both were convincing evidence that this is a chemical age.

"The use of lantern slides in the teaching of organic chemistry," by Dr. Norman Kharasch, University of Southern California. Dr. Kharasch illustrated his talk with some of the slides he makes himself to accompany his mimeographed lecture notes for his organic chemistry classes. He concluded by making a slide in less than two minutes and projecting it.

"The movie review program of the JOURNAL OF CHEMICAL EDUCATION,"[1] by Richard Wistar, Mills College. Dr. Wistar asked for the cooperation of all teachers in this extensive undertaking of evaluating films on chemical subjects, and outlined the points to be commented upon in a review. Through the publication of reviews which represent the composite opinion of several teachers, Dr. Wistar hopes to help teachers make selections with a minimum waste of time and to stimulate producers to make more and better films.

"Joys and sorrows of a teacher of science," by Dr. Joel Hildebrand, University of California at Berkeley. From his years of experience in the teaching of general chemistry, Dr. Hildebrand culled many and various happenings in the remembrances of which the joys far outweighed the sorrows. Among the joys he listed the challenge of each new class, the gratification derived from the accomplishments of former students, and the pleasure afforded by the subject of chemistry itself. Chemistry, according to Dr. Hildebrand, can afford great satisfaction to the teacher because it is a concrete subject, a dramatic subject, a stimulating and growing science, a subject which is basic to the understanding of other sciences, and which is well able to exercise the greatest intellectual capacities of the human mind.

[1] See THIS JOURNAL, 27, 488 (1950).

Report of the

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS

RECENT ADVANCES IN FLUORINE CHEMISTRY[1]

GLENN C. FINGER[2]
Illinois State Geological Survey, Urbana, Illinois

THE phenomenal advances in fluorine chemistry during the past ten years enabled the chemical industry to announce some of the most unusual products known to the industrial world. With grateful appreciation to the press, popular attention was called to the handiwork of the fluorine specialists such as new plastics, lubricants, dielectrics and many other products with superb and unique properties. Even the average student of chemistry was caught by surprise with these announcements on the king of the halogen family. This unawareness is easily understood. Authors of college textbooks have been most parsimonious on the subject, and their abbreviated discussions gave a diabolical undertone to fluorine chemistry, as judged by the reactivity and corrosiveness of the free element and its acid. Little thought was given to the harnessed energy of this element, capable of producing some of the most stable compounds known to mankind. Since the average reader is interested in general information rather than complex theories and reactions the writer has chosen to touch briefly on the occurrence of fluorine, its position in the Periodic Table, fluorine's historic milestones, and the commercial implications of the 1949–50 era.

Fluorine occurs to the extent of 0.03 per cent in the earth's crust, and in spite of this low concentration it is nineteenth in abundance among the elements. Its abundance is two-thirds that of chlorine, three times that of copper, and 15 times that of lead. The chief fluorine minerals are rock phosphate, fluorspar, and cryolite, with fluorine contents of 3.5, 48.5, and 54 per cent, respectively. Cryolite, Na_3AlF_6, is inconsequential because of its scarcity and the strong competitive position of synthetic cryolite from fluorspar. Outside of fluosilicic acid and its salts, which are by-products of the phosphate fertilizer acidulation industry, rock phosphate, $CaFCa_4(PO_4)_2$, is not a convenient source of fluorine. However, it is potentially the world's greatest fluorine reserve (*1*). Fluorspar, CaF_2, is the chief source of fluorine for the chemical industry. The Illinois-Kentucky fluorspar district accounts for over 80 per cent of the production of the United States. Depending upon economic conditions and the depletion of fluorspar reserves, the natural mineral may have competition from a synthetic calcium fluoride obtained by a rock phosphate defluorination process now under investigation by the Tennessee Valley Authority (*2, 3, 4*). Essentially, the process involves the reaction of water with molten rock phosphate, causing the fluorine to be evolved as an impure hydrofluoric acid stack gas and recovered in a limestone-filled tower as calcium fluoride.

The development of synthetic optical calcium fluoride crystals for use in infrared instruments should be mentioned. Because of the scarcity of natural optical material the Harshaw Chemical Company is producing large single crystals by its special cooling process from the molten state. Lithium fluoride crystals are produced in the same way.

Hydrofluoric acid, especially the anhydrous acid, is rapidly becoming a common chemical of commerce, and is produced by the reaction of sulfuric acid on fluorspar in a heated rotary kiln. The production of this acid has progressed in the last decade to carload lots, such as 27,000 tons for 1949 (*5*). A new plant (*6*) completed in 1949 has a production capacity of 600 tons per month and can be operated safely with two operators on a shift. This is a far cry from Marggraf's discovery of the acid in 1768 and the unfortunate experiences of Berzelius, Davy, Gay-Lussac, Thenard, the Knox brothers, Moissan, and others of chemistry's Hall of Fame. The corrosive and toxic properties of hydrogen fluoride cannot be mitigated, but with modern techniques in the laboratory and plant it can be handled safely and with simplicity. Since the acid is fluorine

[1] Presented at the Twelfth Summer Conference, New England Association of Chemistry Teachers, University of Connecticut, Storrs, Connecticut, August 24, 1950.

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chemistry's key chemical, its growth in tonnage production is an excellent index of the broadening impact of a new field of chemistry.

To the uninitiated, fluorine appears to be surrounded with a shroud of mystery, but a glance at the periodic table will reveal some fundamental facts about the Dr. Jekyll and Mr. Hyde properties of fluorine and its compounds. Fluorine occupies the upper right-hand corner, and is the first member of Group VII, the halogen family. It is the most electronegative and most reactive element known. Since it is the first element in the halogen family it has a dual personality, in that it not only has family attributes but also properties quite foreign to the other halogens. If the subject is approached from this point of view the actual picture is much less confusing, and speculation by analogy is tempered with caution.

The two most brilliant scientists of all time in fluorine chemistry are Moissan of France and Swarts of Belgium. They were contemporaries and their studies laid the foundation stones of many of our modern developments. Moissan (*7*) isolated fluorine in the free state in 1886 by the electrolysis of potassium acid fluoride and then studied many of its reactions. Modern cells operating on the same principle are producing fluorine on a tonnage basis. Many of the higher metallic fluorides superficially described by this savant are now available in quantities. The explosive reactivity of fluorine with organic molecules, observed by Moissan, induced Swarts to look for an entirely different method for the synthesis of organic fluorine compounds. In 1892 Swarts announced the synthesis of CCl_3F and $CHCl_2F$ by the reaction of anhydrous antimony trifluoride on carbon tetrachloride and chloroform, respectively. This reaction of an organic chloride with a metallic fluoride and its expanded version is now known as the Swarts reaction. Its industrial significance is expressed in the production of fluorinated derivatives of methane and ethane for use as refrigerants, propellants in aerosol bombs, etc. As early as 1944 the projected production capacity of dichlorodifluoromethane was 2400 tons per month (*8*). In 1949 the production of aerosol bombs alone was 25,000,000 units (*9*). The studies of Swarts at the turn of the century on the fluorinated ethylenes laid the foundation for the new fluorinated polymers that are now beginning to appear on the market. In retrospect, it is quite difficult to divorce present-day advances from the influence of the studies of Moissan and Swarts. Collectively they published over 100 papers.

The 1930–40 decade is especially significant in the industrial awakening and development of fluorine compounds. Prior to this period the only compounds available in commercial quantities were aqueous hydrofluoric acid and some of its more common salts. About 1930, two very important industrial developments took place, the commercial production of anhydrous hydrofluoric acid (*10*) and the new Freon refrigerants (*11*). These industrial chemicals broke the bottleneck of the availability of raw materials. Close on the heels of these developments, new fluorine-containing dyes of unusual stability appeared on the American market from Germany. The I. G. Farbenindustrie in 1933 obtained a patent on the use of HF in the synthesis of aromatic fluorine compounds (*12*), and in 1939 was credited with the first patent on fluorinated polyethylene polymers (*13*).

With the preceding background material, the writer has chosen the 1940–50 decade as the period of recent advances. This period is characterized by the fabulous expenditure of money on fluorine research, the vast amount of experimental data collected, and the unfortunate slanting of research during a war effort.

In 1941 the du Pont Company obtained a patent on a tetrafluoroethylene polymer which is commercially available under the trade name of Teflon. At the behest of the Manhattan Atomic Energy project, the development of the former I. G. chlorotrifluorethylene polymer was expedited and is known as Fluoroethene and Kel-F. These plastics have unique properties (*14, 15*), are very resistant to solvents and corrosive chemical agents, noninflammable, stable over a wide temperature range up to 250°, and possess excellent dielectric properties. For extreme conditions, they are being fabricated into gaskets, diaphragms, electrical insulators, and other items. As suspensoids they are becoming available for coating purposes.

The synthesis of highly fluorinated hydrocarbons is one of the most remarkable achievements in organic fluorine chemistry. Results of this research (*16, 17*) are manifested in the new noncorrosive and chemically inert liquids, greases, and waxes which are now becoming available as dielectrics, fire extinguishers, lubricants, pump oils, hydraulic fluids, magnetic clutch liquids, etc. Essentially they are completely fluorinated compounds with very little unsaturation and hydrogen content. During the war the term "perfluorocarbons" was coined for these compounds as a simple appellation. The methods of synthesis which have been developed can be classified as: (1) polymerization, (2) direct fluorination with gaseous fluorine or higher metallic fluorides, and (3) electrochemical fluorination. The first method depends upon the controlled polymerization of fluorinated ethylenes to the physical state desired; the aforementioned plastics represent the upper limit of polymerization. Higher molecular weight compounds with a $(CF_2)_x$ constitution can be obtained also by a thermal cracking process of $CHClF_2$; tetrafluoroethylene and octafluorocyclobutane are among the products of reaction. A recent discovery (*18*) that CF_3I and C_2F_5I will react with olefins in the presence of ultraviolet light to form long-chain compounds merits watching. These processes have the advantage of using simple compounds produced by the Swarts reaction.

The direct fluorination of hydrocarbons (*19*) with fluorine gas is accomplished in a copper reactor packed with copper shot or gauze. Ordinarily the fluorine

stream is diluted with an inert gas such as nitrogen. A modified and somewhat more convenient method is the passage of a hydrocarbon over certain higher metallic fluorides such as CoF_3 and AgF_2 at a suitable temperature. The net result is that the metallic fluoride goes to a lower valence state by giving up part of its fluorine under more controllable conditions. After regenerating the spent material with fluorine or chlorine trifluoride the cycle can be repeated. This process is known as the Fowler method. Both fluorination processes give rather complex mixtures resulting from the rupture of carbon-carbon linkages, rearrangements, etc. These fluorination studies on organic compounds are spectacular when it is considered that the heat energy released in fluorine substitution and addition is greater than the bond strength energy of any individual linkage in the organic molecule.

Most unique of all processes for achieving the "perfluoro" state is the electrochemical fluorination method announced by Simons in 1948 (*20*). It involves the passage of an electric current (5–6 volts) through an electrolytic cell charged with anhydrous hydrofluoric acid and the organic compound to be fluorinated. The iron cell case is the cathode, and a series of nickel sheets fairly close together make up the anode "pack." No fluorine is liberated, but complete fluorination of the organic compound takes place. The process is capable of producing not only "perfluorocarbons" but also completely fluorinated acids, amines, alcohols, etc. (*21*).

Some fluorinated aliphatic acids such as mono- and trifluoroacetic (*22*, *23*) and heptafluorobutyric (*24*) acids are beyond the laboratory stage. In general, the acids are quite stable, very acidic, and in some cases very toxic. The first reported existence of an organic fluorine compound in nature was announced in 1944 by the isolation of monofluoroacetic acid as the toxic principle in a South African plant (*25*). This acid and its derivatives if taken internally are deadly poisons for which there is no known antidote. A commercial rodenticide (*26*) known as "1080" is the sodium salt of the toxic acid. Thenoyl trifluoroacetone (*27*) is available for the separation of metals through chelate complex formation. Ethyl trifluoroacetate (*27*, *28*) is a pilot plant item and is useful in organic synthesis. Fluorine in place of chlorine in the benzene rings of DDT is the basis of DFDT (*29*) which was produced in commercial tonnages in Germany during the recent war. For the alleviation of certain goitrous conditions two aromatic fluorine compounds under the trade names of Pardinon (*1*) and Capacin (*30*) are available in the German drug trade. Before leaving the subject of organic fluorine compounds, mention should be made of the American production of benzotrifluoride and related compounds (*16*) and the possible use of bromofluoromethanes as fire extinguishing agents.

Tremendous strides were made in the inorganic field. As catalysts, boron trifluoride and HF were recognized as powerful tools in the synthetic organic industry. The tonnage requirement for HF as a catalyst in the production of "alkylate" for 100-octane aviation gasoline (*8*) became enormous after the establishment of the first plant in 1942. It has been reported that some "alkylate" reactors were built for a capacity of 50 tons of HF. Large quantities of HF were used also in the production of fluorine for atomic energy purposes. Fluorine generators operating at 2000 amperes with a current efficiency of 95 per cent and capable of producing 2000 pounds of fluorine per month were developed (*1*). A monthly production of 50 tons of fluorine was reported in Germany before its capitulation. For laboratory purposes a small generator (*31*) is available and is recommended over that of the purchase of fluorine in cylinders. Chlorine trifluoride is on the market in small steel cylinders, and its future as a convenient fluorinating agent is promising. No one has been able to understand why the Germans had contemplated production of this compound in tons except for a possible use in incendiary bombs. The big push in fluorine production came because of its essential use in the production of the atom bomb. Uranium in the form of its hexafluoride has a sublimation point of 56° and as such is amenable to the separation and concentration of its isotopes needed for nuclear energy (*1*). Pure sulfur hexafluoride is extremely stable, nontoxic, noninflammable, and because of its high dielectric value it is used in X-ray equipment as a gaseous insulator (*1*). Potassium fluosilicate is being used in a process for making synthetic mica (*32*). Electroplating in solutions of metallic fluoborates came into prominence.

Among the commercial infants are the fluorophosphoric acids (H_2PO_2F, HPO_2F_2, and HPF_6) and some of their salts. They have been labeled FP acids and salts by their first producer (*33*). The acids exhibit catalytic properties in olefin polymerization, and the salts may be used as fluxing agents. The PF_6^- ion is quite stable, and the HPF_6 acid with certain organic bases forms insoluble salts quite analogous to $HClO_4$ and HBF_4 under the same conditions. Certain organic esters of the monofluoroacid were identified as the very toxic nerve gases (*34*) proposed by the Germans; it has been reported that one of the compounds, di-isopropyl fluorophosphate (DFP), in very low concentrations is useful in medicine. While on the subject of "peculiar" acids and salts, mention should be made of the work of Emeléus at Cambridge (England) (*35*). He has prepared a large number of complex compounds of bromine trifluoride (BrF_3), examples of which are $KBrF_4$, $AgBrF_4$, $Ba(BrF_4)_2$, BrF_2SbF_6, BrF_2PF_6, etc. Evidence points to the fact that BrF_3 is an ionizing solvent, producing BrF_2^+ and BrF_4^- ions. This work opens an entirely new field of fluorine research.

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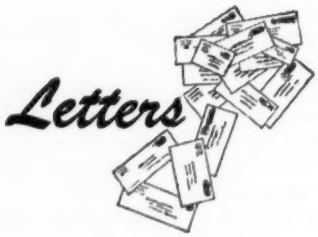

To the Editor:

I have read with much interest Professor Oesper's account, in the October issue of the JOURNAL OF CHEMICAL EDUCATION, of Marcel Delépine's career and work; as a list of the latter's work it is satisfactory but it fails completely to give the reader any idea of the man's kindness, warmth, and humor.

I had the good fortune to work under Delépine in the Collége de France on organic research during the years 1937–1939; his Laboratoire de Chimie Organique was mobilized on the outbreak of World War II, and I was privileged to continue working there, on war work, until the occupation of Paris by the Nazis. The night before the Nazis entered Paris I left that city in my car accompanied by Marcel Delépine, Antoine Willemart, and all the precious metals and cash belonging to the Laboratory. We proceeded painfully along the refugee-packed roads to Tours where the Government had been set up and where we were to requisition one of the University Laboratories and continue our work. The journey was very tiring and not without danger from strafing by the *Luftwaffe* but Delépine's courage and consideration for others was an inspiration to all; he was then in his 70th year but Willemart and I had the greatest difficulty in persuading him to occupy the only available bed rather than share the straw on which we slept when accommodation proved particularly difficult to find. The memory of his philosophical and imperturbable remarks during the *al fresco* meals we enjoyed by the roadside will ever remain in my mind. Here was a man who had led a full and active life, who saw his world disintegrating before his eyes but did not despair; his only worry was for his family from whom cruel circumstances separated him.

Delépine is a devoted and affectionate husband, father, and grandfather. His Normandy farmer origins probably explain his strong sense of family ties and honorable dealing, and the pithyness of his utterances. It probably also accounts for a streak of carefulness regarding money which should not be confounded with meanness; this characteristic is shown in a treasured autograph letter which I possess. The occasion on which this letter was written was the visit of the Président de la République to the Collège de France in order to open the new lecture theatre; it refers to Delépine's acceptance of an estimate for cleaning the windows of his Laboratoire de Chimie Organique before the projected ceremony and he specifies the price (700 francs); adds that work must start first on the side of the laboratory facing the quadrangle through which the Président must pass on his way to the ceremony and must be completed in time for the ceremony or he would not pay for it. I should perhaps explain that the money had to come from Delépine's slender laboratory budget and that although the laboratory was of fine modern design and very well equipped, in all the

time that I was there this was the only occasion on which funds were "squandered" on window cleaning.

Whilst far from being a *gourmand*, Delépine is definitely a *gourmet* and enjoys good food and wine as only a Frenchman or one who has lived in France can.

He is never so happy as when in the laboratory and most especially when he has successfully exercised his unusual knack of persuading the most gummy substances to crystallize cleanly.

If these few words can pay tribute to one of the kindest of chiefs, ablest of chemists, and finest of gentlemen that I have been privileged to meet, I shall be well content.

DENIS DUVEEN

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To the Editor:

The timely paper on "The acceptance of new official names for the elements" in the August issue of the JOURNAL OF CHEMICAL EDUCATION reminded me of three other minor irregularities. These are (*a*) the use of cassiopeium (Cp) for Lutetium, (*b*) the use of the symbol Sa for Samarium (Sm), (*c*) radon being termed niton. These three errors do not occur often, but one can still see them in certain books and papers. It is to be hoped that scientists will use the names and symbols suggested by The International Union, and thereby prevent further unnecessary duplication of terminology.

D. J. SWAINE

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Recent Books

• THE THEORY AND PRACTICE OF SEMIMICRO QUALITATIVE ANALYSIS

G. B. Heisig, Associate Professor of Inorganic Chemistry, University of Minnesota, Minneapolis, Minnesota. W. B. Saunders Company, Philadelphia, Pennsylvania, 1950. Second Edition. 356 pp. 15 figs. $3.50.

THE second edition of Professor Heisig's book is similar to the first except more attention is given to equilibrium constants. Provision is made for using either centrifuges or pressure filter tubes. Standard samples contain 0.1 mg. of each ion present and volumes handled vary from two drops to 1.5 ml.

The book is written for those students who have had a thorough course in general inorganic chemistry. It is intended for a two-quarter, five-credit course or its equivalent. However, it is arranged so that some of the material may be omitted for briefer courses.

The first part of the book is devoted to theory and calculations. A good list of problems and questions is given at the end of each chapter. The second part of the book is devoted to laboratory operations. Many preliminary experiments are given for each of the twenty-four cations and twenty-four anions provided for.

Those teachers who have students qualified for such a course and wish to give a course in semimicro analysis would do well to consider Professor Heisig's book.

RAY WOODRIFF

MONTANA STATE COLLEGE
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• GENERAL CHEMISTRY

P. W. Selwood, Professor of Chemistry, Northwestern University. Henry Holt and Company, Inc., New York, 1950. xvii + 681 pp. 206 figs. 22 tables. 16 × 24 cm. $4.60.

THIS new text is the outgrowth of a lithoprinted edition developed by the author during the last thirteen years for use in a so-called terminal course in chemistry at Northwestern University. The author states in the preface: "The text should demand no less intellectual effort than the standard chemistry text. . . . Whatever success this text achieves will be measured more by what is omitted than by what is included."

At Northwestern University the text is used for a year-course with three lecture periods a week, accompanied by two quiz meetings which are reduced later to one each week. A laboratory manual for one three-hour period a week has been written by the author to accompany the text. The author thinks it is desirable to segregate those who have had high-school chemistry from those who have not, although he finds that it does not seem to make much difference in a course of this type.

A very pleasing narrative style is used by the author combined with what he calls an atomistic approach. Atoms are introduced from an historical treatment of Dalton, and atomic weights by the mass spectrograph. Cathode rays and radioactivity topics lead to the octet theory, which is used to introduce the concepts of formulas and equations. Frequent use is made of sketches of the Fisher-Hirschfelder type of molecular structure models and occasionally interatomic distances and bond angles are given. The first four chapters deal with the concepts of atoms, atomic structure, atomic combinations, and chemical arithmetic. It is not until chapter seven has been reached that the chemistry of one of the elements, namely oxygen, is introduced. By chapter twelve, the fundamental principles have all been presented except for a later chapter on electrochemistry and one on nuclear chemistry. The section on writing and balancing equations seems to the writer to be very brief, throwing the burden of teaching this section to students with no previous chemistry either onto the professor's shoulders or perhaps onto an extra quiz section as provided at Northwestern.

For emphasis of the more important material a set of exercises is given at the end of each chapter. Mastery of these is considered by the author to mean effective mastery of the course, and his quizzes and examinations are based directly upon them. Most of the exercises are divided into separate sections, one to test the student's acquaintance with basic definitions and principles and another to test the ability to reason with such information. Seventy-one additional review problems in chemical arithmetic with answers are included at the end of the book for students who have difficulty with arithmetical problems.

Boldface type is used for emphasis as needed. Sections set aside in smaller type than normal "may be omitted, on first reading, without loss of continuity." Since questions occur in the exercises concerning the material taken up in these sections the student is held for the information anyway. Except for the implication that the student will read the chapter through a second time, it is doubtful that much is accomplished by the use of the small type.

The index covers 17 pages in double columns and is usually made up of words which are in italics in the body of the text. An extreme case is the inclusion of stoves, on p. 387, which reads: "preheating the air (for blast furnaces) is done in large chambers called stoves." The index is very detailed, containing such items as hopcalite, polycythemia, and thenardite. The proofreading has been very carefully done. Only one error was discovered, namely, acrylonitrite in the index actually referred to acrylonitrile.

An unusual feature of the text is the large number of pages devoted to organic chemistry. Of the 657 pages in the book, the last 150 are given to organic chemistry topics. These pages are profusely illustrated with structural formulas for compounds ranging from sucrose, saccharin, quinine, nicotine, and cocaine to estradiol and testosterone.

The choice of material for inclusion in the book is well done, although it was noted that the treatment of the topics of paint, varnish, and lacquers was confined to four lines. A wealth of topics is presented to intrigue the student into going deeper into the subject on his own. For this purpose, frequent references are given at the bottom of the page to authoritative and extended treatments.

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● MAN'S PHYSICAL UNIVERSE

Arthur Talbot Bawden, **Stockton College, Stockton, California. Third edition. The Macmillan Company, New York, 1950. xv + 822 pp. 320 figs. 15 × 22 cm. $4.75.**

Quoting the subtitle, this text is "A Survey of Physical Science for Colleges" and "is intended for use in a program of general or liberal education." It is "designed to bring from the archives of physical science the most important facts and generalizations which have any bearing" on the "problems of life today." The author has "attempted to explain the more important principles" and it is hoped that the study of the text will develop in the student those qualities of mind "that will lead him to attempt to use the scientific method in solving the important problems of life." "One of the fundamental purposes of 'Man's Physical Universe' is to enable students to obtain a sufficient background in the field of the physical sciences to enable them to keep up with the developments of Science and technology by reading such weekly publications as the *Science News Letter* or such monthly publications as the *Scientific American*, the *Science Digest*, and *Science Illustrated*."

It is not clear why "Science" is capitalized in the preceding quotation, while "technology" is not; actually the book is concerned far more with technological advances than with the principles of science. It is to be regretted that discussions of the principles which have led to these advances are frequently inadequate and more often lacking. To the reviewer, the text appears to supplant analytical reasoning with memorization of a vocabulary, to encourage glibness rather than understanding, but it is evidently the intention of the author to arouse interest in science by showing through numerous examples how science pervades everyone's life. "Breadth is striven for, rather than depth." The variety of items mentioned in the text is indicated by the approximately 2500 index entries (about 60% more than in the second edition) from abrasives to Thomas Young, and not omitting the P-59A Airacomet, the Taylor Grazing Act, phthalylsulfacetimide, nor lanac. One must respect the author's industry in compiling these numerous examples of technological progress.

The topics treated in the eighty-five sections are the same as in the second edition. The two final sections of the earlier edition, one on protoplasmic and cellular organization, and one on the progress of civilization, have been omitted, as has also the twelve page bibliography. A few sections have been extensively rewritten, but most of the rewriting consists in the addition of recent applications and new vocabulary. The "Study Questions" found in the previous edition are also included in the third edition, together with a few additional questions.

In this text is a wealth of timely information which could serve for background material for a general education in science. Those who demand no more than this from a text will be pleased with this revision, for this third edition has been brought up to date and a number of lines of text added without major deletions from the previous edition.

W. B. KEIGHTON

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● MOTOR OILS AND ENGINE LUBRICATION

Carl W. Georgi, **Quaker State Oil Refining Corporation, Buffalo, New York. Reinhold Publishing Corp., New York, 1950. xii + 514 pp. 150 figs. 111 tables. 16 × 24 cm. $8.50.**

The author, who is technical director of the research laboratories of Quaker State Oil Refining Corporation, has prepared a specialized book which is limited specifically to automotive motor oils and engine lubrication.

The first part of the book, 7 chapters covering 255 pages, is devoted to specifications, tests, viscosity characteristics, evaluation, and refining of motor oil; also included are additives and synthetic oils. The second part, 18 chapters covering 250 pages, discusses the application of motor oil and the relation of oils and lubrication to engine design, operation, maintenance, breakdowns, and failures. Diesel, aircraft, stationary, and marine engine lubrication are also discussed. Sludge solvents and oil re-refining are treated briefly.

There is much in this book that will interest the chemically-trained automobile owner. Many of his questions, or arguments with service station attendants, will be answered. It is an excellent specialized technical book in an important field.

KENNETH A. KOBE

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● ADVANCES IN COLLOID SCIENCE. VOLUME III

Edited by *H. Mark* and *E. J. W. Verwey,* Polymer Research Institute, Polytechnic Institute of Brooklyn, Brooklyn, New York; and *N. V. Philips,* Gloeilamperfabrieken, Eindhoven, Holland. Interscience Publishers, Inc., New York, 1950. xi + 384 pp. 180 figs. 35 tables. 16 × 24 cm. $7.50.

This is the third volume of this important series in colloid science. The first two volumes appeared in 1942 and 1946, which indicates a spacing of four years between volumes. The science is moving along so rapidly that certainly there should be enough new material in four years to justify a new book. The latest volume is not confined to recent advances, however, nor does the reviewer feel that it should be since there are numerous important topics reaching back two decades yet to be covered.

The book opens with a 66-page treatise on interatomic forces and adsorption at surfaces, by J. H. deBoer. It is mainly a review of old and fairly well-established principles with only 18 per cent of the references to work within the past decade. A serious effort has been made to give quantitative relations, but due to the paucity of our knowledge of the real structure of surfaces, of the magnitude of the repulsive forces, and of the real distances of adsorbed atoms from surfaces, many calculations lead only to the correct order of magnitude. The subject is divided into (1) combination of attraction and repulsion forces, (2) interaction between a surface and adsorbed ions and radicals, (3) van der Waals forces, (4) collaboration between forces, and (5) reactions at the surface.

The second chapter on surface chemistry and colloids by A. E. Alexander is devoted mainly to the behaviour of high molecular

weight substances in films, offering interpretations of phenomena observed with proteins, polymers, foams and emulsions, pastes, and biological systems in the light of recent work. It provides a framework of information with 60 selected references, mainly to work within the past decade.

Next is a chapter on the quantitative interpretation of the electrophoretic velocity of colloids by J. Th. G. Overbeek. It is devoted mainly to a quantitative interpretation of electrophoretic mobility, with a modest degree of success. More and better experimental data are needed for comparison with theory.

The following chapter on lyogels by E. A. Hauser and D. S. LeBeau discusses gel structure and stability and the authors' views on thixotropy, rheopexy, dilatancy, and elasticity. The treatment of these subjects is sketchy and makes no substantial contribution to the literature. The electron photomicrographs and ultraphotomicrographs shown are of high quality and do give some support to the authors' theory of elasticity, which deserves consideration by those working in this field. It is unfortunate that the theory does not include the kinetic explanations which seem to be so well founded.

The chapter on ultracentrifugal sedimentation of polymolecular substances by Per-Olof Kinell and Bengt B. Ranby is directed mainly toward the problems of molecular weight, shape, and weight distribution in linear polymers. The ultracentrifuge is one of the few basic instruments for the determination of molecular weight and has been particularly productive in the field of proteins where the molecules are globular, but it has not been so successful with the linear polymers due to the complexity of the sedimentation process. As a basic tool in this field it is important to develop the technique further, and this chapter is a valuable contribution. Such subjects are treated in detail as sedimentation properties of linear molecules, change of shape in a centrifugal field, influence of branching, solvation, shielding, dependence on concentration, polymolecularity, frequency distribution, and fractionation. Detailed attention is given to cellulose nitrate, methyl methacrylate, and styrene.

Next follows a systematic treatise on fatigue phenomena in high polymers, by J. H. Dillon, covering general principles, fatigue of rubbers, fibers, and plastics. The subject is exceedingly complicated, involving at least six basic parameters. Much experimental work reported in the voluminous literature is of little value due to the failure to control experimental conditions properly.

The last 54 pages of the book are devoted to a qualitative description of the art of flotation, by Strathmore R. B. Cooke. Attention is given to frothers, collectors, activators, and depressants. The industrial importance of the process is tremendous, but as yet only an inadequate scientific foundation has been laid. Judging by the fact that only one-fourth of the references are to work within the past decade, one concludes that there is relatively little activity in this field outside of commercial developments.

SAMUEL S. KISTLER

NORTON COMPANY
WORCESTER, MASSACHUSETTS

● A TEXTBOOK OF INORGANIC CHEMISTRY

J. R. Partington, Professor of Chemistry in the University of London, Queen Mary College. Macmillan and Co., Ltd., London, 1950. Sixth edition. x + 996 pp. 394 figs. 14.5 × 22.5 cm. $3.75.

THE latest edition of this popular textbook of inorganic chemistry, while containing considerable rewritten material, has achieved a certain degree of condensation over the fifth edition of 1937 by the elimination of the most elementary material and questions for exercise (the latter being relegated to the same author's "College Course of Inorganic Chemistry" and his "Intermediate Chemical Calculations." An extension of the sections on atomic structure and the electronic theory of valence, with new material on directed bonds and resonance, has improved this part of the book, as has the inclusion of a fuller account of the rarer elements and of recent theoretical and experimental advances in this field of chemistry.

Realization of the growing significance of the structural aspects of inorganic chemistry finds reflection in the subject matter, especially of Chapters XXI to XXV. It is refreshing to note, in this regard, that while the author has included in the text various descriptions of molecular and crystal structures, he takes occasion, in the Preface, to caution the student to the effect that "this information cannot replace a detailed knowledge of the preparation and properties of substances, which forms the most important content of the subject of their studies. It bears the same relationship to the latter as anatomy does to physiology." This attitude toward the rapidly growing fund of structural inorganic information impresses one as particularly sane and commendable.

The author's readable style and his penchant for giving his account a pleasing historical flavor, especially to be noted in the earlier chapters, are maintained in the present revision, many of the figure and cuts being retained from the previous editions.

Although some of the descriptions of industrial production methods are applicable to European practice and are not always relevant to usage in this country, their inclusion does not prevent effective use of the book in American classes.

As a reasonably-priced, convenient, and concise source of the essential facts and theories of inorganic chemistry, the latest Partington book maintains its high standing among the leading textbooks in the field.

WALTER C. SCHUMB

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASSACHUSETTS

● UNIT OPERATIONS

George Granger Brown and Associates in the Department of Chemical Engineering, University of Michigan. John Wiley and Sons, Inc., New York, 1950. xii + 611 pp. 551 figs. 64 tables. 22 × 28.5 cm. $7.50.

"THE King is dead! Long live the King!" Since 1923 "Principles of Chemical Engineering" has ruled the chemical engineering students as the text from which the professional work was absorbed. Initially the chemical engineering course at many schools consisted of the chemistry curriculum with one year devoted to a study of "Principles," so it is no wonder that the book achieved fame as "The Bible" of chemical engineering. But time marches on; and additional textbooks devoted to stoichiometry, fuels and combustion, thermodynamics, kinetics, unit processes, and process industries opened up new subdivisions of chemical engineering to which additional time had to be devoted. At most schools the "Principles" became a study of the unit operations of chemical engineering—flow of fluids, flow of heat, evaporation, distillation, absorption, extraction, size reduction, separations, and the like. The first edition in 1923 was followed by a second in 1927 and a quick brush-over in 1937—the science of chemical engineering has made strides since then!

G. G. Brown and eleven of his associates in the Department of Chemical and Metallurgical Engineering at the University of Michigan have presented in "Unit Operations" not only an up-to-date text on the subject but a new viewpoint on the teaching of the unit operations. The unit operations are grouped according to similarities in action or in methods of calculation and presented in sequence according to increasing difficulty. Part I on solids requires little background to understand the discussions of properties of solids, screening, size reduction, and handling of solids. Part II on fluids covers not only the conventional flow of fluids through pipes, but also through porous media, which leads to filtration. The flow of solids through fluids is part of the basic phenomena, so that classification, flotation, and sedimentation become an integral part of this section. Being thoroughly modern, a chapter on fluidization of solids brings this subject to the senior level. Part III on separation by mass

transfer under equilibrium conditions (the ideal stage concept) deals with leaching, extraction, distillation, and adsorption. The Ponchon method is presented for distillation calculations. Part IV on energy and mass transfer rates presents those operations in which the time rate of transfer is the important factor. These operations are heat transfer, evaporation, crystallization, agitation, absorption, humidification, and drying. An appendix collects the nomenclature used throughout the book and presents in tables and charts additional data needed for the solution of problems.

Although from the preceding paragraph it might be assumed that each unit operation is treated as such, this is not the case. The fundamental physical chemical principles of the group of unit operations are elucidated and shown in their broad application before they are narrowed down to specific unit operations. To consider distillation alone would require portions of a number of earlier chapters. This stress on fundamentals is what the teaching profession desires—industrial practice may vary and adapt, but the fundamentals govern the practice. Some confusion may result in those courses that have followed the unit operations sequence given in other texts. The authors have furnished a mimeographed outline which suggests assignments from their book for a number of courses of different lengths, but each instructor will have to integrate the new material with his own sequence of presentation.

The size of the book brings something new to senior texts. The page size of 8.5 × 11 inches allows extra large charts to be used so that values can be read accurately from them. The text matter is arranged in two columns on the page. In addition to the graphs of data and illustrative charts there are numerous and excellent illustrations of industrial equipment used in the various unit operations, so that the student can see the way in which the theory is applied through machinery. Illustrative problems are used freely and each chapter is concluded with a number of problems for student use. References to the original literature are given.

This text will be used widely in chemical engineering instruction. It will also be used widely as a reference text by practicing engineers. Because it stresses fundamentals, the chemist will refer to it frequently in connection with the application of physical-chemical principles or the equipment used for chemical operations. It should be available in all chemical libraries.

KENNETH A. KOBE

UNIVERSITY OF TEXAS
AUSTIN, TEXAS

● BORON TRIFLUORIDE AND ITS DERIVATIVES

Harold Simmons Booth, **late Hurlbut Professor of Chemistry, Western Reserve University; and** ***Donald Ray Martin,*** **Assistant Professor of Chemistry, University of Illinois. John Wiley and Sons, Inc., New York, 1949. ix + 315 pp. 43 figs. 41 tables. 14 × 22 cm. $5.**

WITHIN recent years the investigation of the stability of addition compounds formed by typical Lewis acids, such as boron trifluoride, has contributed much to present knowledge of the factors affecting the strength of chemical bonding. Such Lewis acids are excellent catalysts, and there has also been intense activity in investigating the numerous reactions catalyzed by boron trifluoride. A book which thoroughly reviews the literature on boron trifluoride should therefore be exceedingly useful to workers in the field.

The scope of the book is indicated by the chapter headings:

I. History and Preparation of Boron Trifluoride.
II. Physical Properties.
III. Chemical Properties of Boron Trifluoride.
IV. The Coordinating Power of Boron Trifluoride.
V. Fluoboric Acids and Their Salts.
VI. Boron Trifluoride and Its Derivatives as Catalysts.
VII. Analysis of Boron Trifluoride and Its Derivatives.
VIII. Practical Handling of Boron Trifluoride.

It is unfortunate that the authors have made little effort to assimilate the material and to write a critical survey. As is the case with many review books published today, the book is primarily a series of abstracts of individual contributions. This style does not make easy reading. For example, instead of discussing the general properties of addition compounds of the aliphatic ethers and boron trifluoride, the authors devote some four pages to individual statements of the preparation of individual compounds. A typical sample of the presentation (p. 69) follows:

"The compound comprised of 2 moles of diethyl ether to 1 mole of boron trifluoride, $BF_3 \cdot 2O(C_2H_5)_2$, is listed by Meerwein and Pannwitz.[589]

"Methyl ethyl ether-boron trifluoride, $BF_3 \cdot O(CH_3)(C_2H_5)$, was reported by Meerwein and his coworkers in 1937.[557] Many of its physical properties have been reported[494] (see Table 17).

"Methyl amyl ether-boron trifluoride, $BF_3 \cdot O(CH_3)\ (C_5H_{11})$ has also been reported.[558]

"Ascending the aliphatic series, we find that normal propyl ether and boron trifluoride form the compounds $BF_3 \cdot (n\text{-}C_3H_7)_2O$[559] and $BF_3 \cdot 2(n\text{-}C_3H_7)_2O$.[559]

"Isopropyl ether and boron trifluoride form the solid $(i\text{-}C_3H_7)_2O \cdot BF_3$.[113] Isopropyl methyl ether-boron trifluoride also has been listed, $(CH_3)_2CH \cdot CH_3 \cdot O \cdot BF_3$.[559]"

Several instances were found where the authors obviously misquoted the original publication. For example, the following statement (p. 47) taken from a publication by the reviewer does not make sense and bears no resemblance to the original.

"A pyridine derivative, α,α'-lutidine, forms a coordination compound with boron trifluoride which is a stronger base toward HCl than the pyridine compound with boron trifluoride.[110]"

As a result of the presentation adopted by the authors, the nomenclature used is identical with that used in the original publications. Thus the same substance is frequently referred to by several different terms within the span of a page or two. There is little attempt to be critical. The substance, "sodium fluoborax"

$$Na_2 \left[F_3B \overset{\cdot\cdot}{:\underset{\cdot\cdot}{O}:} BF_3 \right]$$
$$F_3B \qquad\qquad BF_3$$

is mentioned in a number of places as though its structure were established, although the material is mentioned only in the patent literature and no evidence is presented in support of this unusual structure. The so-called addition compounds of boron trifluoride and argon are discussed in great detail although Wiberg's work, which appears to discredit the existence of such compounds, is not mentioned.

Finally, the authors' attempts to suggest theoretical explanations are misleading. Thus, it is noted (p. 70) that the failure of boron trifluoride to combine with diphenyl ether is probably due to steric hindrance. The reviewer is not one to minimize the importance of steric effects. However, in the present case the weak coordinating ability of the oxygen atom is more probably attributed to the resonance effects of the aromatic rings. The authors suggest (p. 44) that in the addition compounds of ethanolamine with boron trifluoride the latter might be attached to the oxygen atom. Certainly in this case the nitrogen is the more basic atom, and it is far more probable that the boron trifluoride is attached to this atom. They state (p. 86):

"In doubly bonded oxygen atoms, sp^2 orbitals are not available. Hence boron trifluoride would not be expected to coordinate with truly doubly-bonded oxygen atoms, such as the CO group in esters. Coordination with ketones may be with their enol form."

Not only is the theoretical basis of this conclusion highly doubtful, but the statement ignores the experimental fact that stable addition compounds are formed by boron trifluoride with

trimethylacetaldehyde, benzaldehyde, and benzophenone. Obviously in these cases enolization is not possible.

Space limitations prevent pointing out numerous other errors and deficiencies. These severely limit the utility of the book. In its present state it is a highly dangerous book for students to read since it may lead them into many erroneous theoretical concepts. Its major utility will be to investigators expert in the field who are sufficiently well versed in the field not be led astray by the errors in the interpretation and fact, and who will no doubt find it convenient to have available a summary of the literature for easy reference.

HERBERT C. BROWN

PURDUE UNIVERSITY
LAFAYETTE, INDIANA

• LABORATORY MANUAL OF ELEMENTARY ORGANIC CHEMISTRY

E. Campaigne, Associate Professor of Chemistry, Indiana University, Bloomington, Indiana; *Harold Hart,* Assistant Professor of Chemistry; and *Robert D. Schuetz,* Assistant Professor of Chemistry, Michigan State Collete, East Lansing, Michigan. Wm. C. Brown Company, Dubuque, Iowa, 1950. x + 197 pp. 11 figs. 21.5 × 28 cm. Planographed. $2.50.

• LABORATORY MANUAL OF ORGANIC CHEMISTRY

George H. Coleman, Dean of the Institute of Textile Technology, Charlottesville, Virginia; *Stanley Wawzonek,* Associate Professor of Chemistry; and *Robert E. Buckles,* Assistant Professor of Chemistry, The State University of Iowa, Iowa City. Prentice-Hall, Inc., New York, 1949. x + 127 pp. 24 figs. 21.5 × 28 cm. $1.50.

THESE manuals are of the paper-covered, workbook type. Report sheets only are perforated and punched in the first manual (Manual 1), while in the second manual (Manual 2) all pages are so treated. Manual 1 has a spiral binding. Both manuals are neatly arranged and the variety of experiments in each is such that the student should gain an adequate experience in the laboratory in his particular course.

Manual 2 offers a wider latitude since it is designed for a two-semester or three-quarter course with two laboratory periods of three hours each per week. Manual 1 is designed for a one-semester or one-quarter course. Manual 2 contains 50 experiments covering 60 laboratory periods, and Manual 1 contains 25 experiments. In Manual 1, considerably more emphasis is placed on the so-called test tube experiments, roughly two-thirds being of this type. The report sheets are therefore somewhat more lengthy in this manual. There are questions on all the report sheets of both manuals and in many cases there are problems in Manual 2. There are 32 strictly preparative experiments in Manual 2 and 10 test tube experiments.

The directions in both manuals are clear and concise. The text of Manual 2 is confined solely to experimental directions; the theory and principles are to be discussed by the instructor in the laboratory conference. There are very brief expositions of theory and principles in Manual 1 but these would require an elaboration in the laboratory conference. Both manuals include a section on the materials and reagents required for each experiment.

In the interest of economy and safety, the authors of both manuals have designed the experiments so that relatively small quantities of organic reagents are used. The authors of Manual 2 indicate that the experiments in their manual are on a semi-macro scale and that the largest glass vessels employed are a 250-ml. Erlenmeyer and a 400-ml. beaker. The preparative experiments in Manual 2 are consistently on a smaller scale than those in Manual 1. However, of the nine preparative experiments in the latter, six require 10 grams or less of the organic reagents.

The sodium fusion technique for the detection of nitrogen, sulfur, and halogens is not used in Manual 1. In fact no test for sulfur is indicated and the test for nitrogen involves the detection of ammonia during the alkaline hydrolysis of acetamide. Metallic sodium is employed in Manual 1 in the experiment on alcohols and phenol.

The most novel features of Manual 2 are the strictly semi-macro scale, a page devoted to directions in case of accident, and the avoidance of ethyl alcohol. Isopropyl alcohol is used as a substitute for ethanol when an alcoholic solvent is required, and ethylene is prepared from ethylene dibromide.

The reviewer feels that Manual 1 is more inclusive than most manuals of its type. Because of its general character, Manual 2 has many attractive features to recommend it.

DONALD C. GREGG

UNIVERSITY OF VERMONT
BURLINGTON, VERMONT

• CHEMICAL ENGINEERING REPORTS

Kenneth A. Kobe, Professor of Chemical Engineering, University of Texas, Austin, Texas. Third edition. Hemphills Bookstore, Austin, Texas, 1950. vi + 69 pp. 3 figs. 21.5 × 27.5 cm. $1.

"PARTICULARLY in the field of report writing do we find the average graduate to be woefully lacking."

The above is typical of the many comments with respect to report writing heard from industrial representatives in recent years. This small book should be useful as a guide to the preparation of reports, not only to the chemical engineering student, but also to chemistry students and young graduates in industry.

The book has itself been prepared in the format of a formal engineering report presenting material on the literature of chemistry and chemical engineering and its assembly into a report. The section on "The Chemical Literature" is a useful summary of common sources of information such as books, abstract journals, technical journals, public documents, O.T.S. and F.I.A.T. reports, patents, manufacturers' publications, etc. It is primarily confined, however, to American sources, including very little about foreign literature.

Reports are usefully classified and discussed by type such as information, examination, research, and recommendation reports and by form of presentation such as the letter, text, and formal report.

The sections on "Mechanical Preparation" and "Literature Citation" contain a wealth of useful information not only to the student but to any one faced with the preparation of technical data in report form. Thus, the use of the typewriter for Greek letters, and mathematical equations and conventions as to charts and graphs and the typing of literature references can serve as a guide to all.

S. RICKLIN

BROWN UNIVERSITY
PROVIDENCE, RHODE ISLAND

• CHEMISTRY AND INDUSTRY OF STARCH

Edited by *Ralph W. Kerr,* Corn Products Refining Company, Argo, Illinois. Second edition. Academic Press Inc., New York, 1950. xii + 719 pp. 16 × 24 cm. $11.50.

EVEN a chemist might be hard pressed to name the parent material common to ingredients used in the manufacture of gum drops, paper bags, mayonnaise, postage stamps, and the sheet of coated paper on which these lines are written. The answer, of course, is starch, as a colloidal gel, dispersing agent, or as adhesive, and this illustration only serves to demonstrate the diverse applications of the commonplace material starch.

This authoritative book discusses thoroughly the occurrence and varieties of starch, the processes used in its preparation, its physical and chemical properties, its chemical reactions and how it can be modified, and the uses to which it can be applied. It should prove of great value to the well-trained chemist who desires to become familiar with this specialized branch of carbohydrate chemistry, the technologist who desires to find the right material for a specific application, the teacher who is continually striving after greater background in the details of chemistry and its application to our civilization, or to the chemistry student preparing a term paper. In certain excellent sections the discussions are concerned with such matters as molecular rotation, degree of polymerization, straight or branched chain structure, hydrogen bonding, and the fine details of colloidal behavior. Extensive background is necessary to read such specialized material with full understanding. On the other hand, most of the sections are descriptive in nature and can be highly instructive even to the layman. Dr. Kerr and his nine coauthors have done excellent work in preparing a book of wide appeal.

In the chapter on the Derivatives of Starch the anhydroglucose units of starch are written as though they were primarily derivatives of pyran with the hetero atom at the top, rather than in the Haworth formulas recently recommended by the American Chemical Society Committee on Nomenclature. Although the formulas employed may have superiorities over the Haworth structures from a pedagogical standpoint, it seems to the reviewer that their use in a book of this kind is unfortunate, since the conventions employed are not explained and another type of formula does not give much comfort to a newcomer to the field. These remarks are not intended, however, to detract from the otherwise excellent review of starch derivatives presented.

For the benefit of those familiar with the first edition of this book it should be mentioned that the chapters on The Manufacture of Corn Starch, Chemical Properties of Starch, and Uses of Starch and Starch Products in the Fermentation Industries have been completely rewritten. In addition, two new chapters have been added, Miscellaneous Uses for Starch and Methods of Analysis for Starch. Other chapters such as Occurrence and Varieties of Starch, Manufacture of Modified Corn Starches, Derivatives of Starch, and Uses of Starch in Paper Manufacture have been extensively revised. The remaining chapters are essentially as they appeared in the first edition. The bibliographies at the end of most chapters have been greatly expanded.

It is natural that the editor of this book, because of his association with the Corn Products Refining Company and because of the dominant position that cornstarch holds in industry, should place his major emphasis on this particular variety of the carbohydrate. A great deal more can be said about other varieties of starch than is contained in this book and it is to be hoped that other books in the field will be forthcoming.

IRWIN B. DOUGLASS

UNIVERSITY OF MAINE
ORONO, MAINE

● INDUSTRIAL CHEMICALS

W. L. Faith, **Director of Engineering, Chemical Division, Corn Products Refining Company, Argo, Illinois;** ***Donald B. Keyes,*** **Vice-President, Heyden Chemical Corporation, New York; and** ***Ronald L. Clark,*** **Fellow, Multiple Fellowship of the Corn Products Refining Company, Mellon Institute, Pittsburgh, Pennsylvania. John Wiley & Sons, Inc., New York, 1950. xi + 652 pp. Illustrated. 15.5 × 24 cm. $8.**

IN A conversation with Dr. Faith the reviewer learned that the idea for this book came from one of a series of articles the reviewer published in the JOURNAL OF CHEMICAL EDUCATION in 1933 on the "Economic Survey of a Chemical Commodity." When Drs. Faith and Keyes were with the War Production Board in 1942–45, they continually needed economic data on the various industrial chemicals which had to be allocated or controlled by W.P.B. Following the war these two, aided by R. L. Clark, began to assemble the technical and economic information on 107 important industrial chemicals.

Each of these chemicals has been treated as an individual with little reference to others included and is discussed with respect to:

1. Name and chemical formula.
2. Manufacturing processes, simplified flowsheets, and important process variables.
3. Equations for the principal reactions involved, average yield.
4. Raw material requirements, sometimes utility and labor requirements.
5. Production chart for past 20 years.
6. Generalized use patterns.
7. Price chart for past 20 years.
8. Commercial grades, containers, shipping regulations, physical properties.
9. Economic aspects, competitive processes and products, recent trends, actual and economic plant size and approximate plant cost (in 1946).
10. A U. S. map showing the location of manufacturing facilities.

Of the 107 chemicals surveyed, 34 are inorganic and 73 are organic. No references are given to the chemical literature; to allow the reader to go to original sources, but the information given is up-to-date and some is unpublished from W.P.B. sources.

This book will be used by the man in chemical industry or the instructor who wishes to secure a technical and economic survey of a chemical or group of related chemicals. It can be used as a text in chemical economics or to supply economic data or viewpoints to a course which presents only technical information. The individual surveys can serve as models for surveys to be made by students—who will then appreciate the amount of effort that has gone into this book.

KENNETH A. KOBE

UNIVERSITY OF TEXAS
AUSTIN, TEXAS

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New Publications

SCIENTIFIC RUSSIAN

A Textbook for Classes and for Self-Study

By JAMES W. PERRY, *Massachusetts Institute of Technology.* 1950. 6 × 9. 846 pages. $7.50

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NATURAL AND SYNTHETIC HIGH POLYMERS

A Textbook and Reference Book for Chemists and Biologists

By KURT H. MEYER, *Professor of Organic Chemistry, University of Geneva, Switzerland. Second completely revised and augmented edition.* 1950. 6 × 9. 912 pages, 186 illus., 80 tables. $15.00

MONOMERS · *A Collection of Data and Procedures on the Basic Materials for the Synthesis of Fibers, Plastics, and Rubbers*

Edited by E. R. BLOUT, *Polaroid Corporation, Cambridge, Mass.*, and H. MARK, *Institute of Polymer Research, Polytechnic Institute of Brooklyn, N. Y.* 1951. 6½ × 9½. Consisting of 14 monographs collected in ring binder, totalling 644 pages, 46 illus., 47 tables. $12.50 including binder.

TECHNIQUE OF ORGANIC CHEMISTRY

Editor: ARNOLD WEISSBERGER.

Volume IV: DISTILLATION

1951. 6 × 9. 696 pages, 293 illus., 97 tables. $14.00

Contributors: Arthur and Elizabeth Rose, Arthur L. Glasebrook, Frederick E. Williams, Carl S. Carlson, John R. Bowman, R. Stuart Tipson, Edmond S. Perry, John C. Hecker.

Volume V: ADSORPTION AND CHROMATOGRAPHY

By HAROLD GOMES CASSIDY, *Sterling Chemical Laboratory, Yale University, New Haven, Conn.* 1951. 6 × 9. 370 pages, 53 illus., 54 tables. $7.00

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WHATMAN Ashless Tablets are an excellent source of such pulp. They have so little ash that it can be safely ignored, they break up easily to form a smooth, even suspension in distilled water and they are comparatively inexpensive.

You can either make up a stock suspension or use a portion of a tablet for individual analyses.

Always keep a supply of WHATMAN Ashless Tablets on hand as you will find many uses for them.

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There's no need to hunt through half a dozen bulky catalogs to locate the materials you want for student experiments, or for your demonstration work.

In the CamboscO Order Book you'll find descriptions and prices for 7781 items, of which 1601 are pictured. Throughout the listing of apparatus, numbered illustrations are interspersed, for instant identification.

Detailed Dimensional Data

For every piece of apparatus that is made in more than one size, complete dimensional data are given. Pyrex Test Tubes, for example, are offered in twenty sizes and styles. For each, the listing shows: length, diameter, rubber stopper size, price per dozen, number in case and price per case.

This unique method of listing, in which a single page equals two or three pages of an old style catalog, eliminates some "sales talk", but omits none of the information essential for intelligent choice.

For teachers who prefer them, there is included a liberal supply of conventional order blanks, printed on special paper, on which it is easy to write with hard pencil, soft pencil, ink, or ball point pen. Those perforated blanks have proved especially convenient for interim orders.

An Annual Publication

Once a year, the CamboscO Order Book is painstakingly revised, from cover to cover. New items are added. Obsolete or unavailable materials are dropped. Prices are brought up-to-date at the moment of publication.

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The CamboscO Order Book is furnished, without charge or obligation, to science teachers and to school officials.

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Cambosco SCIENTIFIC CO.

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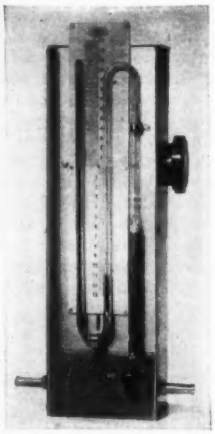
BOSTON, MASS., U.S.A.

Out of the Editor's Basket

Manometer

The new Teschner-Machlett Manometer with Bennert scale has been announced by E. Machlett & Son, 220 East 23rd Street, New York 10, New York. This instrument overcomes the shortcomings of the old type Mercury manometer, namely, easy breakage of glass parts due to exposed construction, freezing of stopcocks, necessity of manually raising and lowering the scale which frequently sticks and freezes, and inaccuracy in readings due to difficulty of manipulating the scale over small distances. The new manometer is made entirely of metal with the exception of the manometer "U" tube itself which is of glass but so protected and supported within the housing as to reduce breakage to a minimum. Even if broken it is easily and inexpensively replaced. In addition the tube has a dust filter trap which materially reduces danger of contamination of the mercury.



A balance type chain device conveniently controlled by a large plastic hand wheel permits rapid and precise scale adjustment over both small and large distances. An "on-off" knob opens and closes a precision ground metal stopcock which is impervious to mercury vapors. A key slot located on the back of the instrument permits wall mounting.

Sodium Shot

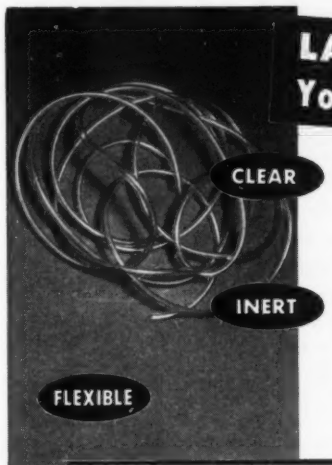
Metallic sodium in shot form is being offered in research quantities by Pierce Chemical Company, Rockford, Illinois. It is furnished in uniform size, 1–2 mm. in diameter, under xylene, but larger sizes and other inert media will be available. It is intended for use in the laboratory where sodium in the form of wire, ribbon, chips, or slices is now employed, and its use should make sodium press operations unnecessary. For dispensing to students, shot of 6–8 mm. size could be transferred from a bottle with tweezers. With smaller shot the xylene-sodium shot slurry is transferred by pouring and the sodium measured by weight or volume. The xylene is readily removed and replaced with another liquid if desired.

Adhesive Label Tape

An adhesive tape known as "Labelon Tape" has been announced by Will Corporation, Rochester 3, New York. It is fabricated in three plies, transparent cellulose, carbon, and adhesive, and can be written on with any pointed instrument. Markings cannot be erased, and, with the tape, are water-, oil-, dirt-, and smudgeproof as well as acid resistant. However, the surface becomes impaired above 65°C. The tape adheres to metal, plastic, glass, etc., without moistening, but can be removed easily, if desired. It comes in roll form in a container with a metal cutting bar.

Openings for Chemists

Positions are open for chemists in the newly organized Geophysical Research Directorate of the Air Force Research Laboratories, Cambridge, Massachusetts. Salaries range from $4000 to $10,000 per year, and full information can be had from the U. S. Civil Service Commission, Washington, D. C.



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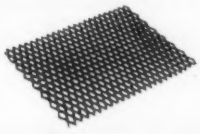

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Any lab looks better, serves better when equipment, walls and ceiling are painted with Tygon corrosion-resistant plastic Paint. Series "K" Tygon Paint is made from the same basic resins as Tygon Tubing . . . doesn't require a primer . . . goes on easily by brush or spray without any unconventional surface preparation. The wide range of colors will meet almost any decorative requirements. Ask your laboratory dealer about Series "K" Tygon Paint. Try it. You'll like it.

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Glass breakage costs mount up. A Tygoflexed "Protecto-Grid" in the bottom and on the drain boards of your laboratory sink will pay for itself very quickly. The soft, resilient Tygoflex covering absorbs shock — saves valuable glassware, reduces accident hazard. The tough, long-wearing plastic shrugs off laboratory corrosives. "Protecto-Grids" are made in a range of sizes to fit all standard laboratory sinks. Your laboratory supply dealer can tell you all about them.

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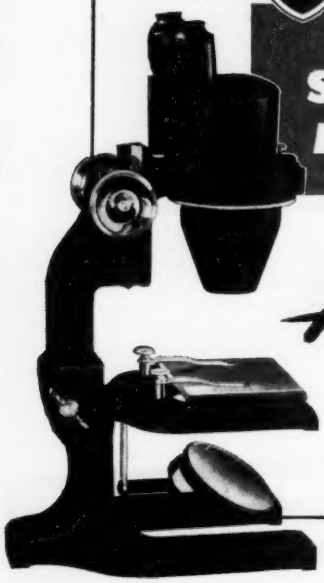

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These precision instruments are indispensable in mineralogy, metallurgy, small parts inspection, critical assembly operations, food processing, science teaching. See your AO Spencer distributor for a demonstration, or write Dept. N67.

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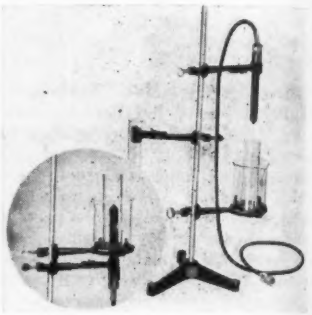
Liquid Counter Set

A special set of equipment designed to speed up and simplify laboratory work with solutions containing radioactive materials has been announced by Nuclear



Instrument and Chemical Corporation, 229 West Erie Street, Chicago 10, Illinois.

In addition to standard laboratory pieces, such as ring stand and necessary clamps, the set also includes a special Marinelli type beaker and a support on which the beaker can be mounted. A plug-in type counter is provided with the set over which the Marinelli beaker can be placed.

As part of this set, a test tube of correct size is also provided so that the Geiger tube may be used as a dip counter. For beta counting the test tube is filled with 20 cc. of the active liquid which then covers the sensitive area of the counter.

This counter is all glass and is easily decontaminated. The Marinelli beaker may be used only for gamma counting since a heavy glass wall is interposed between the liquid and the counter. The advantage of this method is that the counter is not contaminated in any way and, therefore, many solutions may be checked without the necessity for cleaning the counter each time.

Rubber Sample Kit

A new rubber sample kit containing materials for 11 classroom experiments has been prepared by United States Rubber Company, Public Relations Department, 1230 Avenue of the Americas, New York 20, New York. It is designed for use in the upper grades of grammar school, and in high-school classes.

The kit contains samples of liquid latex, foam rubber, rubber thread, natural smoked sheet, synthetic rubber, cured black rubber, and cured white rubber. An illustrated booklet gives directions for the experiments and describes rubber's properties, the tapping of the rubber tree, production of synthetic rubber, manufacture of finished products, and the use of rubber in everyday life.

The kit may be obtained by writing for "Rubber Sample Kit" and enclosing 30 cents in coins.

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Accurate

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Accutint is accurate—to 1 pH in the wide range paper and to 0.3 pH in the fractional range. Wide range papers are recommended where the pH value is not known to be within the limits of a fractional range paper. Fractional range papers are used for greater accuracy after the range has been determined.

S-65277 ACCUTINT TEST PAPERS. Packed in glass vials, each vial contains five pads or 100 strips. Color chart and instructions are included with each vial. Per Vial **$0.65**
Per 72 Vials ..... **10% Discount**

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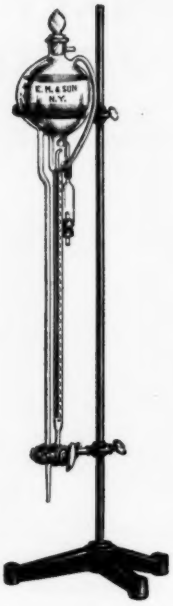
One Stopcock Controls All Action
MACHLETT Auto-Burettes and Pipettes



The automatic action of Machlett Auto-Burettes and Auto-Pipettes measures and delivers a specified volume of fluid accurately, quickly and conveniently. Control is simplicity itself—a half-turn of the stopcock handle fills; another half-turn empties. Machlett Auto-Burettes and Auto-Pipettes are made to Bureau of Standards specifications, in the sizes listed below and to special sizes. Furnished in amberized glass at a slight increase in price.

71-645 Pipettes, Machlett Automatic, Pyrex, gravity filling with support

Pipette capacity, ml.	5	10	25	50
Reservoir cap., ml.	1000	1000	2000	2000
Each	$20.50	21.50	23.00	24.00

8-526 Burettes, Machlett Automatic, Pyrex, gravity filling with support

Capacity, ml.	2	5	5	10	25	50
Subdivisions, ml.	0.01	0.02	0.05	0.05	0.1	0.1
Reservoir cap., ml.	500	1000	1000	1000	2000	2000
Each	$22.50	23.75	23.00	25.00	27.00	28.50

Write for Bulletin A-B

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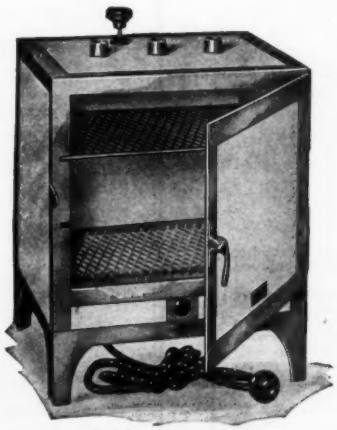

Catalog No. 1078

- **Asbestos transite exterior.**
- **Welded frame—18–8 stainless steel.**
- **Thermostatically regulated to 180°C.**
- **Positive control within ± ½°C.**
- **Pilot light.**
- **Heating chamber—10"H, x 12"W, x 10"D.**
- **Removable heating units—660 watts.**
- **Six foot cord and plug furnished.**

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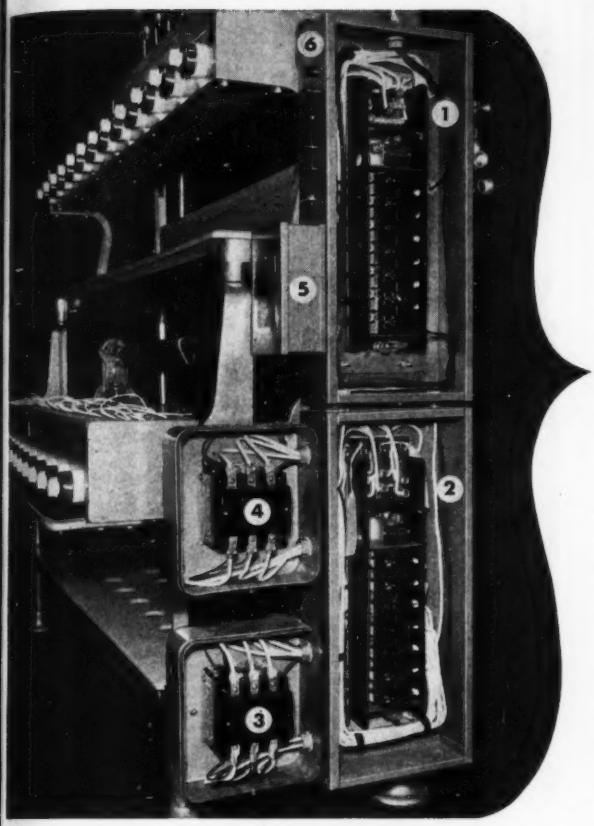


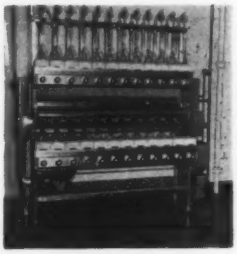
Here's the INSIDE STORY on new features of "Labconco" Electric Kjeldahl Apparatus:

1 and 2 — Branch circuit panels with front removed. New "pushmatics" provide automatic tripping under overload or short circuit. A flip of the finger resets them. This new safety feature is another Labconco "first!"

3 — Magnetic contactor, operated from digestion timer (5). Just set the timer and go about your work — your digestions automatically cut off at the proper moment!

4 — Magnetic contactor, operated from pushbutton station (6). Just push a button — off goes all current to your distillation apparatus. Another "Labconco" safety feature!

Continual improvement of product, quality materials and know-how are responsible for "Labconco" leadership in Kjeldahl manufacture. Write today for pictures, prices, users, and complete details.



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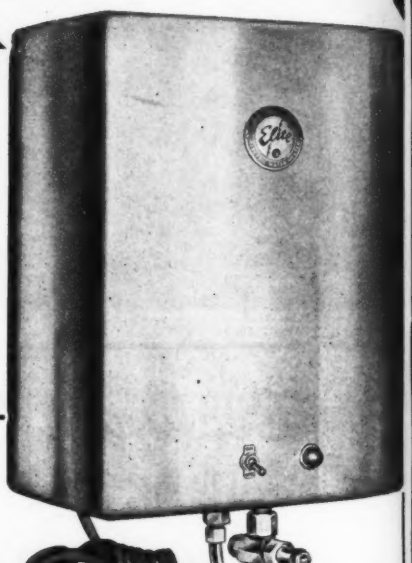

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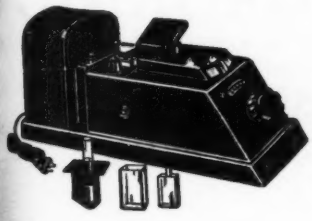

Photoelectric Glass Cell Colorimeter

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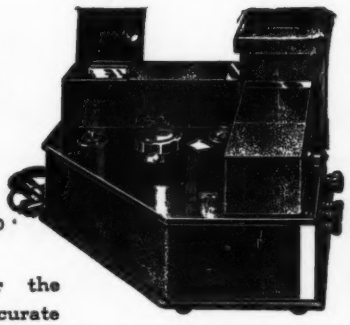
No. 2070



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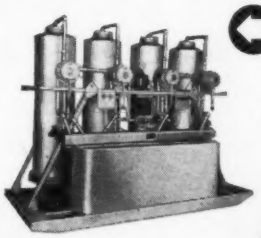
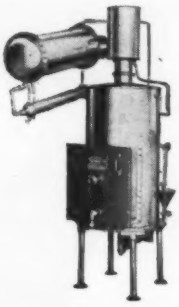


Barnstead Demineralizers produce mineral-free water of far *higher* purity at *lower* cost with a *minimum* of maintenance. Whether you need 5 gallons an hour or 1000 . . . you'll find there's a Barnstead Demineralizer to *fit* your requirements and *save you money*.



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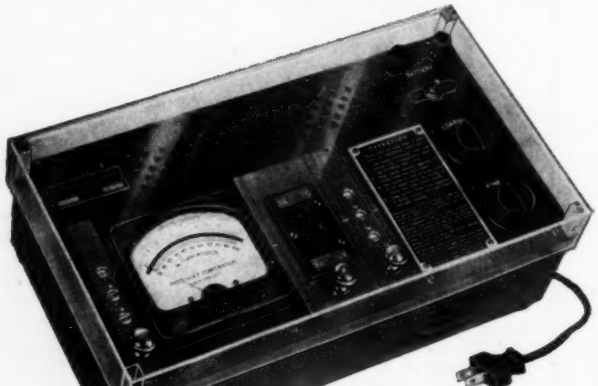
for accuracy, ease, and speed of operation in colorimetric and turbidimetric analysis



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For use with tubes and precision cuvettes
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In rigid metal housing with Plexiglas cover

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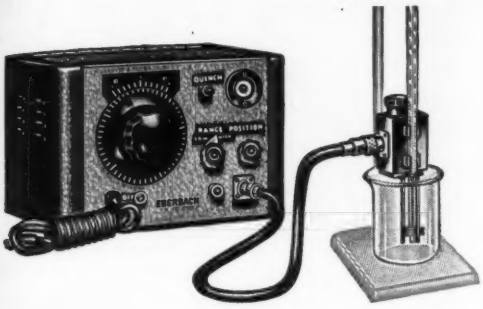

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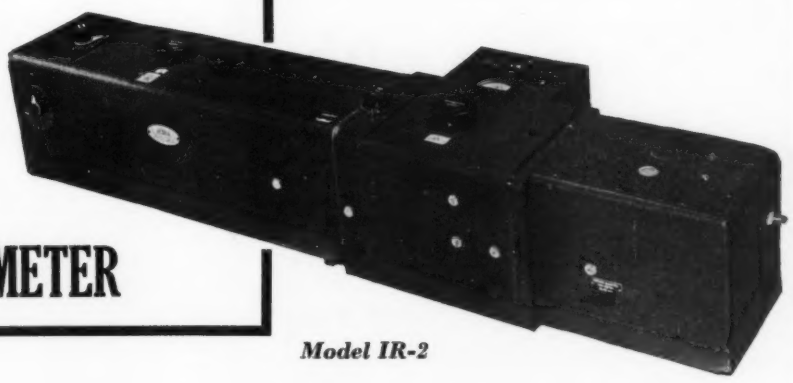

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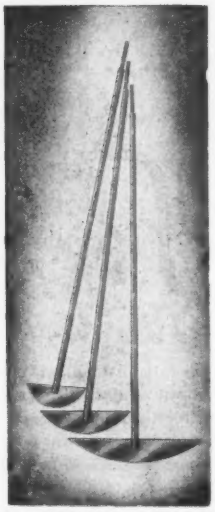

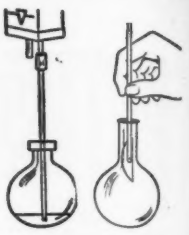

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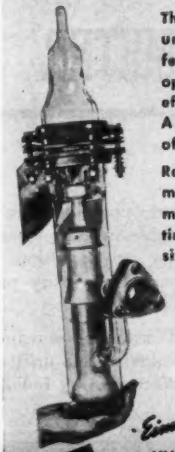

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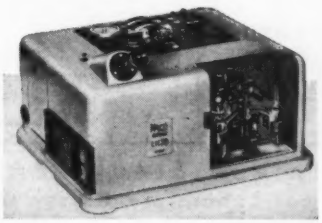

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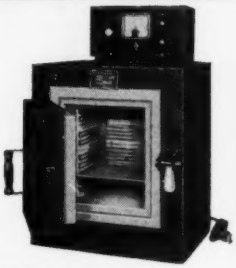

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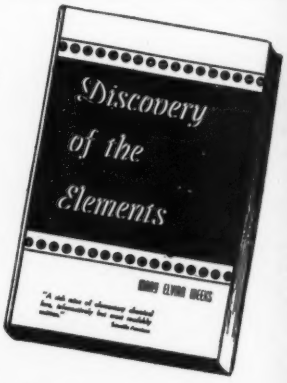

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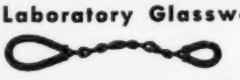

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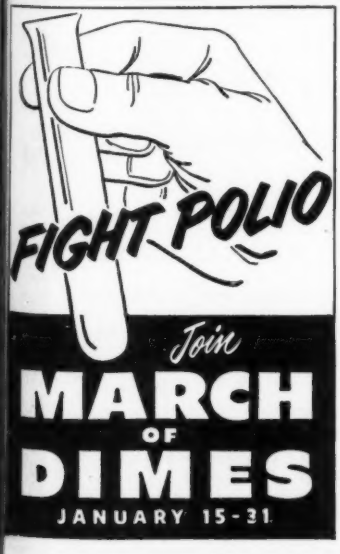

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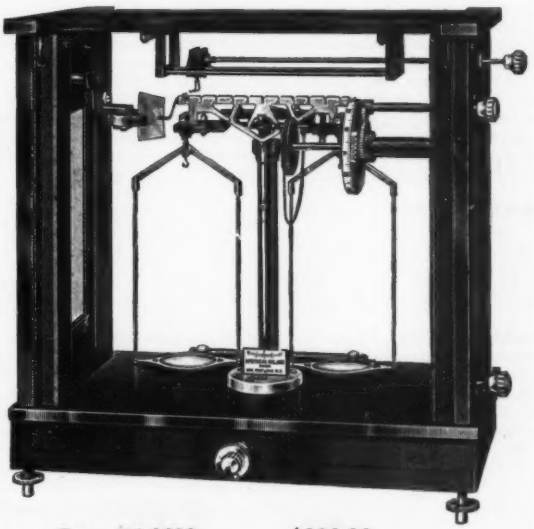

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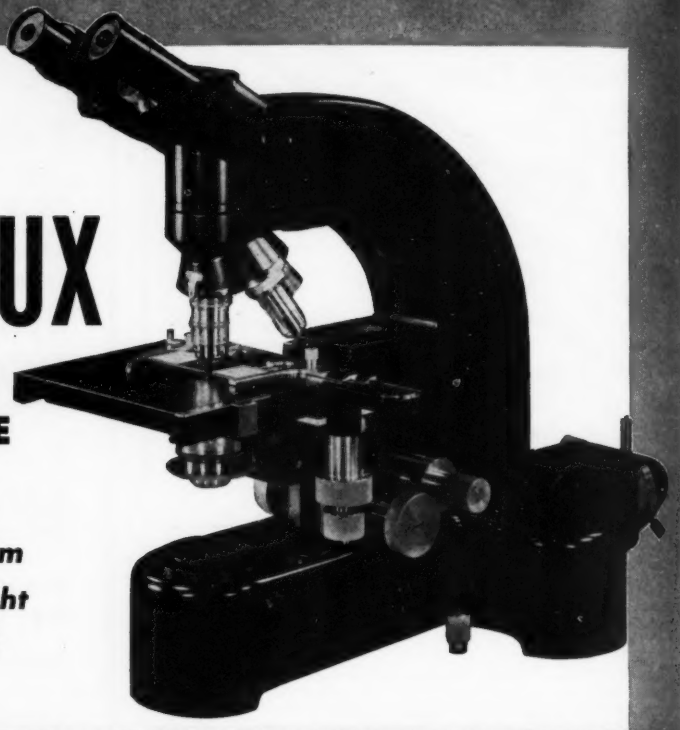

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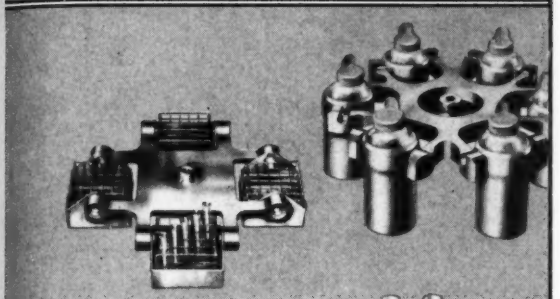

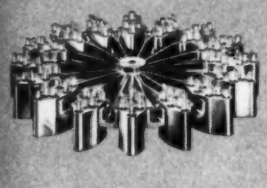

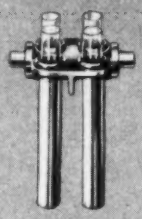

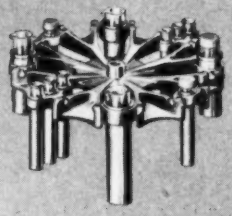

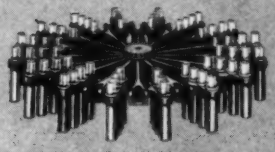

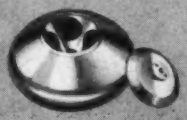

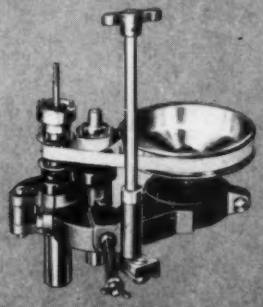

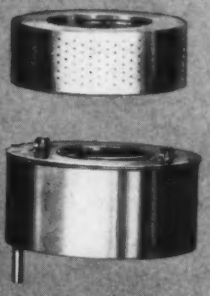

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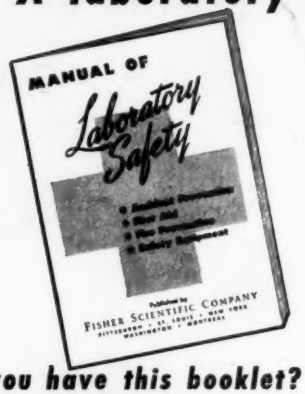

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